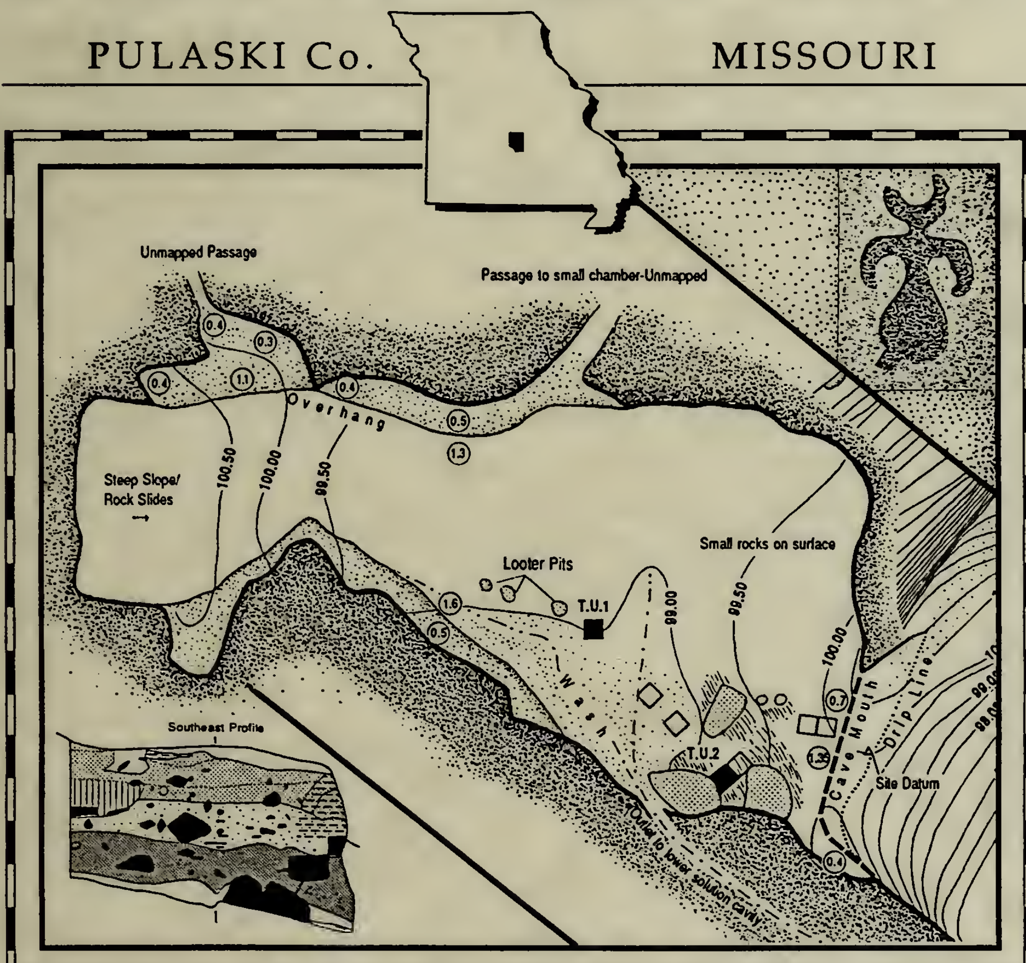
EXCAVATION AND RESOURCE EVALUATION OF SITES 23PU2, 23PU255 AND 23PU235 (MILLER CAVE COMPLEX),

FORT LEONARD WOOD

PULASKI Co. MISSOURI



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PUBLIC SERVICE ARCHAEOLOGY PROGRAM

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ABSTRACT

In 1994, the Public Service Archaeology Program of the University of Illinois at Urbana-Champaign conducted research-oriented excavations and site evaluation at three sites (23PU2, 23PU255 and 23PU235) on Fort Leonard Wood Military Reservation, Missouri, which are part of the Miller Cave Complex. This work was conducted for the United States Army Construction Engineering Research Laboratory (USACERL), and was funded through the Department of Defense Legacy Resource Management Program. The investigations were designed to assess the current state of preservation and scientific potential of the sites, collect information that contributes to regional research issues, and develop appropriate site preservation plans. All three sites had previously been determined eligible for listing in the National Register of Historic Places (NRHP). Site 23PU255 (Miller Petroglyphs), though badly damaged by vandalism, contains the only petroglyphs known from Fort Leonard Wood. Site 23PU2 (Miller Cave) has been damaged by vandalism and previous archaeological work, but was found to contain intact cultural deposits that should enhance our understanding of Late Woodland and Early Archaic cultures of the region. Site 23PU235 (Sadie's Cave) contains nearly intact cultural strata (although past vandalism has occurred) whose occupation spans most of the Holocene. The artifacts and preserved organic remains provide documentation of both human use of the site and paleoenvironmental conditions. It is recommended that the surface of Miller Cave should be restored to near its original contour and that access to portions of this site containing intact strata be restricted. Efforts should be made to recover fragments of petroglyphs removed from 23PU255 by local collectors, and the site should be fenced to limit physical access while providing a view of the rock art. Access to Sadie's Cave should be restricted by fencing to preserve the important Holocene cultural and environmental record contained within its deposits.

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ACKNOWLEDGMENTS

Interdisciplinary projects are almost by definition the product of many individuals' efforts. Moreover, a successful interdisciplinary project, analogous to a complex system, consists not only of the individual analytical contributions, but also includes the interrelationships and communications among the contributors. I consider the Miller Cave Complex project to be an example of successful interdisciplinary effort. I take this opportunity to extend my thanks to the individuals who collectively made this project possible and successful.

First and foremost, I would like to thank Richard Edging, the Fort Leonard Wood Cultural Resource Manager, for his efforts to initiate this project. His faith in my abilities to oversee and manage the fieldwork and analyses has been a source of continuing support through a period of sometimes trying work. He provided the opportunity and the means to investigate these sites systematically and to conduct the analyses in such a way as to make a real research contribution to our understanding of the cultural resources of Fort Leonard Wood and the region as a whole. I sincerely hope that this report justifies his efforts.

I also wish to thank my coworkers and coauthors at the Public Service Archaeology Program at the University of Illinois at Urbana-Champaign for their contributions to this report. Though the primary author is responsible for the overall fieldwork, analyses and interpretations, these overall interpretations could not have been made without the detailed analyses provided by my colleagues. Greg Walz conducted the archaeobotanical analyses, and he was a source of several interesting discussions about the site and its regional implications. Paul Kreisa analyzed the bone, and his struggle with the flotation samples is much appreciated. Brian Adams collaborated with me in an interesting comparative analysis of the lithic modified items, and I believe that we both learned a good deal from the experience. Cindy Balek provided a soil geographer's perspective on the sediment analyses, and her contributions to my growing understanding of sedimentary analysis are highly valued. In addition to my coauthors who reside at PSAP, other nonresident coauthors and analysts also gave their best efforts to this project. Jim Theler found the time to analyze the gastropod assemblages, even though the pay was a mere pittance. Bob Warren conducted his usual thorough and precise analyses of mussel shell. Eve Anderson Hargrave confirmed and corrected my preliminary analysis of the human skeletal remains. I gratefully thank all of these individuals for the timely completion of their analyses. Kevin McGowan at PSAP provided administrative support for the project, left me alone, and gave me free rein to conduct the analyses as I saw fit (as long as it came in within the budget). Finally, Jacqueline McDowell provided technical editorial comments on the manuscript, which has resulted in an improved final product. However, any errors of fact that still reside in this report are the responsibility of the primary author.

The field personnel for this project worked hard and played hard. In addition, it is my fervent hope that they learned things along the way. For their hard work, hard play and hard minds, I extend my gratitude. The quality of the final product is only as good as what goes into it, and the following people gave their best efforts to ensure that the initial documentation and excavation work was the best that could be done. Their skills have greatly enhanced the content and quality of the report:

Brian Adams	Stacy Craft	Tally Moskovits
Todd Brenningmeyer	Larry Fink	Jo Stokes
Pennie Copley	Randy Fink	Richard Edging (guest archaeologist)

Laboratory analysis is also a demanding aspect of any project. For example, sorting flotation samples requires the patience of Job, a low satisfaction threshold and a lack of allergies. For their humor and patience in the face of these difficult and exasperating tasks, I extend my thanks to the following laboratory personnel:

Brian Adams	Pennie Copley	Stacy Craft
Randy Fink	Matt Frye	April Hawkins
Dave Hixson	Ilona Matkovski	Jo Stokes
Greg Walz		

In addition to these people, indirect but still crucial support was obtained from other sources as well. Susan Brannock-Gaul provided the excellent artifact illustrations, site maps and profiles included in this report. Administration of a large project calls for expertise from a variety of people in many different areas. I would like to thank specific people whose administrative efforts I am aware of; I also acknowledge that there are probably others who supported the project in some way, but I remain ignorant of their specific contributions. Tom Riley, former Principal Investigator and faculty sponsor of PSAP, was ultimately responsible for hiring me, and his efforts have made it possible for me to complete this final project. I hope that you are pleased with the outcome. Kathy Bowman and Lynn Richardson (Points-of-Contact at the U.S. Army Construction Engineering Research Laboratory) facilitated the administration of the contract and provided help and clarification when needed. Steve Klein also provided support in his role as payroll coordinator.

To these people I acknowledge my debts. I hope that your experiences in this project have been as rewarding as my own.

PART I

BACKGROUND INFORMATION

CHAPTER 1
INTRODUCTION

In July 1994 the United States Army Construction Engineering Research Laboratory (USACERL) contracted with the University of Illinois at Urbana-Champaign to conduct research evaluations of three sites in the Miller Cave Complex at Fort Leonard Wood, Pulaski County, Missouri. The project was funded through the Department of Defense Legacy Resource Management Program, which is designed to provide funding for research-oriented investigation of cultural and environmental resources, especially in situations where funding would not be available through the usual regulatory programs that focus on compliance with current environmental regulations. The project was executed by personnel from the University of Illinois Public Service Archaeology Program, with fieldwork conducted in September and October 1994. This report details the results of these investigations, provides site evaluations for these three sites, and develops recommended site protection/stabilization plans for each site.

As part of the effort to comply with federal regulations regarding historic preservation, specifically the National Historic Preservation Act of 1966, as amended, and Army Regulation 420-40, large-area Phase I cultural resource inventories have been conducted at Fort Leonard Wood since 1981, resulting in identification of over 290 historic and prehistoric sites. Additional investigation of sites to establish their eligibility for inclusion in the National Register of Historic Places, or NRHP, (Phase II evaluation) has been recommended for about 70 sites. Phase II NRHP evaluations were conducted at all three of the Miller Cave Complex sites investigated here (see Ahler et al. 1995; Markman 1993). A fourth site in the complex (23PU288) recently has been evaluated for its NRHP eligibility (Kreisa 1995) and a fifth site in the complex (23PU254, a cairn) has been recommended for site preservation and stabilization because it most likely contains human skeletal remains. Up to this time, most archaeological research on Fort Leonard Wood has been directed toward site inventory rather than Phase II evaluation; in the last two years formal Phase II evaluation has been conducted at 22 sites, and there are plans to evaluate an additional 12 to 13 sites.

Unfortunately, there are circumstances in which Phase II evaluation provides enough information to assess NRHP eligibility but not enough to address regional research issues or to evaluate the scientific potential and integrity of the site fully. This situation holds for the Miller Cave Complex sites investigated here. All have been determined to be eligible for listing in the NRHP, but full research potential of the sites could not be explored. Nor could a fine-scaled evaluation of site integrity and damage assessment be determined. Fortunately, the Department of Defense has instituted the Legacy Resource Management Program, which is designed to address just these kinds of issues and provide funding for research-oriented evaluation of both cultural and natural resources. The Legacy Program provides support for evaluations conducted under Section 110 of the National Historic Preservation Act for research-oriented scientific evaluation of important sites located on federal land but which are not threatened with direct and immediate impact through federal actions. Section 110 investigations are conducted in addition to or in conjunction with investigations required for site inventory and NRHP eligibility evaluation, which are part of Section 106 procedures. The ultimate goal of the Legacy Program is to enhance the Army's ability to manage effectively the cultural and natural resources that are included within their installations. This project was funded through a successful Legacy Program proposal, and was designed to enhance the Phase II NRHP evaluations conducted previously, obtain and analyze representative samples of

artifacts from all intact contexts, assess the damage done to the sites, and develop plans for site preservation and/or stabilization based on the results of these investigations. It is hoped that additional Legacy Program projects will further enhance both our understanding and effective management of the cultural and natural resources of Fort Leonard Wood.

The sites investigated here are 23PU2 (Miller Cave), 23PU255 (Miller Petroglyphs), and 23PU235 (Sadie's Cave). All of these sites have been previously investigated, and all have been determined eligible for inclusion in the NRHP (see Ahler et al. 1995; Markman 1993). The additional work conducted through this project was envisioned to fulfill three interrelated goals. First, all of the sites needed additional documentation and evaluation of their integrity and research potential above and beyond the minimum investigations that were made for determination of NRHP eligibility. Second, the project was designed to document and collect artifact and paleoenvironmental samples from undisturbed contexts if these were determined to exist. Finally, the project was designed to provide a damage assessment and develop site preservation and/or stabilization plans for all three sites. All of the sites had suffered varying degrees of vandalism from artifact collectors. Large portions of Miller Cave and Miller Petroglyphs had been destroyed through uncontrolled excavation and removal of rock art with chisels and hammers. Though most of Sadie's Cave was intact, it was believed to be only a matter of time before this site suffered the same fate.

The project was designed to address all three of these concerns—additional evaluation of integrity and scientific research potential, documentation/sampling of intact cultural contexts prior to their destruction, and development of damage assessments and site preservation plans. In addressing these goals, it was expected that we would also be able to make substantive contributions to our understanding of local and regional culture history, make refinements to our current knowledge of regional prehistoric settlement and subsistence patterns, and perhaps contribute to our understanding of prehistoric environmental conditions and human adaptation to and interaction with the dynamic Holocene environment of Fort Leonard Wood. It is in this context of interrelated goals of research, site evaluation and site protection that the Miller Cave Complex project was undertaken.

The sites investigated are located in the Big Piney cultural resource zone (Edging 1992) portion of Fort Leonard Wood (Figure 1). This cultural resource zone lies within the northeast quadrant of the installation. The zone is dominated by the Big Piney River valley and also includes the adjacent bluff crests, deeply dissected uplands and several minor tributary stream valleys. The Big Piney River follows a convoluted course that has deeply downcut through the local cherty dolomite bedrock. The valley contains evidence of numerous downcutting and filling events in the form of at least seven terraces that range in age from Pleistocene to modern times (Albertson et al. 1995).

The Miller Cave Complex is a series of six closely spaced and potentially functionally or temporally related sites, located on the crest and face of the southeast-facing bluff overlooking the Big Piney River valley in Pulaski County, Missouri (Figure 1). The site complex is named for Miller Cave, 23PU2, the largest cave site in the complex and one which has had a long history of excavation and archaeological activity. The remaining sites in the complex include Sadie's Cave (23PU235), the Miller Petroglyph site (23PU255), Miller Cairn (23PU254) and two large open habitation sites (23PU288 and 23PU362) located on the bluff crest above Miller Cave, Sadie's Cave and the Miller Petroglyphs. Potentially related sites that are located within about 1.0 km of Miller Cave include 23PU3 and 23PU4, large village sites located in the Big Piney floodplain south of

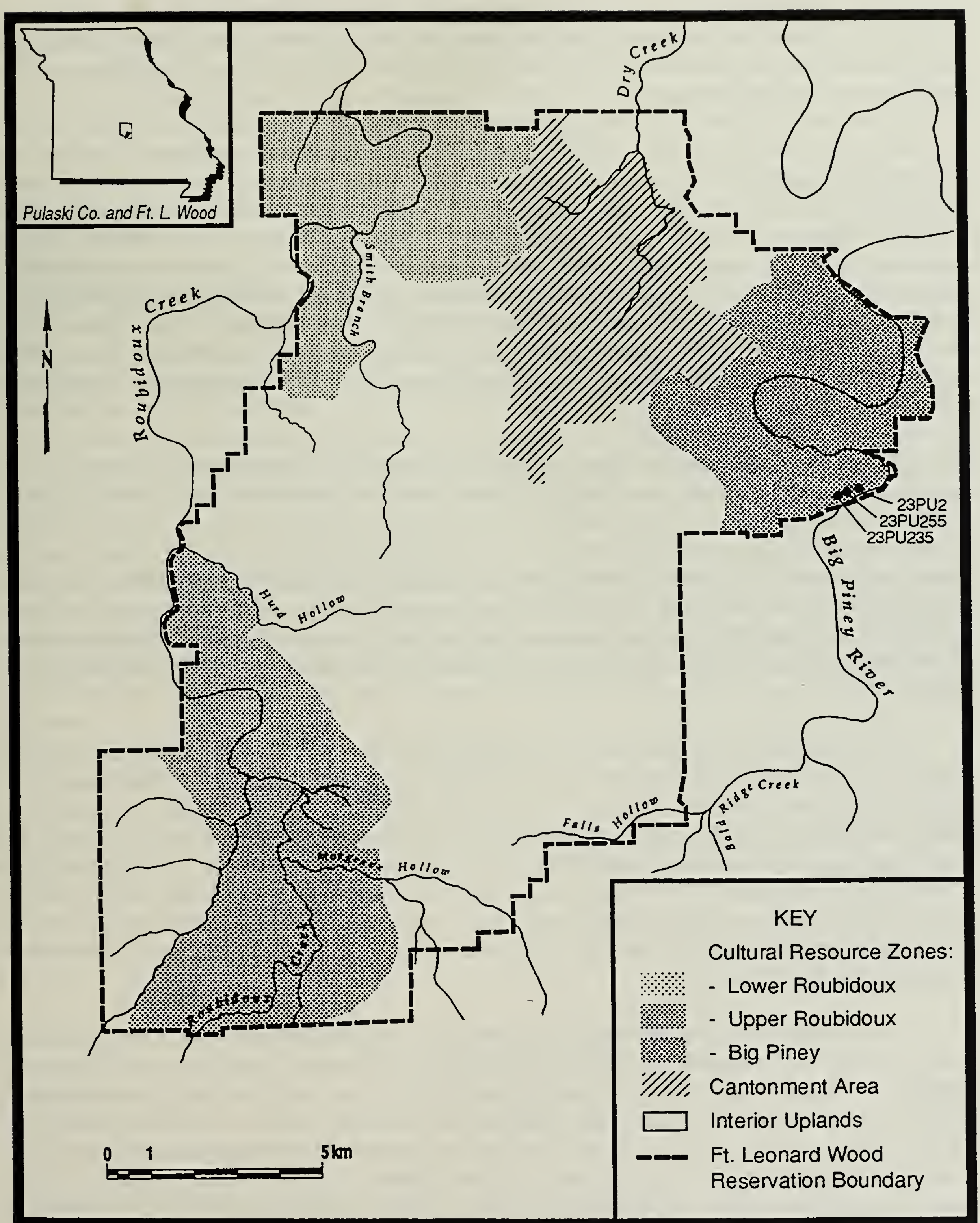


Figure 1. Cultural Resource Zones within Fort Leonard Wood and Location of Investigated Sites Relative to These Zones.

Miller Cave, and 23PU361, an extensive bluff crest habitation site at the east end of the upland ridge that contains Miller Cave. Ultimately, Miller Cave will be included in a larger interpretive project designed to provide the public access to natural, historical and archaeological sites within an 11-km corridor of the Big Piney River.

Three of the Miller Cave Complex sites have been subjected to Phase II evaluation to determine their eligibility for inclusion in the NRHP. Miller Cave was the focus of one of the Smithsonian Institute's intensive cave excavations in 1920 (Fowke 1922), and this site produced thousands of lithic, ceramic, bone, and shell artifacts as well as over 40 human burials. Since its excavation by Fowke, numerous local amateur archaeologists and relic hunters have reexcavated the Miller Cave sediments and expanded the excavated area to include most of the well-lighted portion of the cave interior. Most recently, Markman (1993) performed limited test excavations within Miller Cave to determine if any intact deposits were present. He documented intact Early Archaic sediments and artifacts in the main chamber, and the site has since been determined eligible for listing in the NRHP.

In 1993, the University of Illinois conducted Phase II evaluations of both Sadie's Cave and the Miller Petroglyphs (Ahler et al. 1995). After limited test unit excavation, Sadie's Cave was found to contain at least 1.1 m of intact stratified deposits, dating at least as old as the Middle Archaic period (7,800 years ago); site use was documented to have continued through the Late Woodland period. The site has been determined eligible for listing in the NRHP. The Miller Petroglyphs were found to be highly disturbed by vandalism, with many of the engraved rock faces having been removed in the last ten years. In spite of the damage to the site, portions of the rock art remain intact, and this unique cultural resource has been determined eligible for listing in the NRHP.

Only one of the remaining sites in the Miller Cave Complex has been subjected to Phase II evaluation. Because of the sensitive nature of cairns and their likelihood of containing human remains, there are currently no plans to excavate the Miller Cairn (23PU254); instead, site preservation is the preferred option. The large open habitation sites (23PU288 and 23PU362) on the bluff crest above the caves were reported by Moffat et al. (1989); their report recommended Phase II evaluation of both sites. 23PU288, the larger of the sites, has been evaluated for NRHP eligibility status; recent excavations (Kreisa 1995) found intact, unplowed culture-bearing soil horizons on most of the upland crest with discreet artifact concentrations evident. This site has been recommended as eligible for NRHP listing.

As a result of the 1992 excavations by Markman, the Fort Leonard Wood Cultural Resource Manager submitted a research proposal to the Department of Defense Legacy Resource Management Program. Originally, work was to focus only on Miller Cave, with the goal of determining the extent of intact deposits within this badly disturbed site. When the Phase II findings at Sadie's Cave were revealed, the original proposal was expanded to include intensive test excavations at Sadie's Cave, evaluation of the Miller Petroglyphs, and development of site preservation plans for all three sites. The Legacy program administrators agreed to provide additional funds for an expanded and redefined research program that would investigate three of the Miller Cave Complex sites. This approach seemed to be reasonable in light of the fact that the sites are in close proximity and the high probability that all sites in the complex may be functionally and temporally interrelated.

This report provides the information required in the Statement of Work provided by USACERL. The report is arranged to provide more general information first, followed by site-specific descriptions, development of research goals, and discussion of results. Part I is essentially background information and includes Chapters 1 through 4. Chapter 1 introduces the project and major project goals, and Chapter 2 provides a brief description of the environmental setting of the Fort Leonard Wood region and the Miller Cave Complex locale. Chapter 3 contains a summary of local cultural/historical framework used in this report and a review and critique of previous work performed in and near Fort Leonard Wood. Chapter 4 provides a general research orientation for the project. Part II contains three chapters (5 through 7), in which are presented detailed site descriptions, a review and critique of previous work, development of site-specific research goals and methods, description, analysis and interpretation of research findings, and preliminary evaluations for each of the three investigated sites (23PU2, 23PU255 and 23PU235, respectively). Part III contains an overall evaluation of the research goals of the project (Chapter 8), and develops more detailed site evaluations and site preservation plans (Chapter 9), based on the results of the investigations. References Cited are followed by appendices, which include a detailed list of mussel shell analyzed from Sadies Cave (Appendix A), a curation list of artifacts from each site (Appendix B), and copies of all relevant correspondence, field notes, maps, and laboratory analyses, grouped by site (Appendix C). Appendix C is bound and distributed separately since the information in it is confidential.

All artifacts recovered during this project are the property of the U.S. Government and shall be delivered to Fort Leonard Wood or a repository designated by USACERL. The field and laboratory documents generated by the project have been submitted to USACERL with this final report. Skeletal material and associated grave goods will be inventoried under an agreement with the U.S. Army Training and Doctrine Command (TRADOC) and the St. Louis District Corps of Engineers.

CHAPTER 2
ENVIRONMENTAL CONTEXT

Fort Leonard Wood is located in south-central Missouri in the northern Ozark Highland region, within the Salem Plateau (eastern) portion of the Missouri Ozarks (Loomis 1937; Miller 1981). Structurally, the Ozark region consists of a broad dome of Cambrian to Pennsylvanian sedimentary rock covering an apical core of pre-Cambrian igneous rock. The Salem Plateau is dominated by Ordovician-age dolomites and limestones that have been uplifted and subsequently incised and dissolved by groundwater over a long period of time, forming steep-sided meandering valleys with dendritic drainage patterns and karstic landscape features (Department of the Army 1980:15; Rafferty 1980:8). Local relief differences often exceed 60 m within a radius of 300 m.

The numerous caves, solution cavities, rock shelters, and sinkholes in the region are characteristic of karstic landscapes. These landscape features were formed by groundwater dissolving underlying limestone and dolomite bedrock along bedding planes, fissures or other irregularities (Atwood 1940). These features afforded inhabitants of the region natural shelter from the elements; most larger caves and shelters in the region have evidence of periodic use for spans of several hundred or thousand years. The distribution of caves and rock shelters is not even across the landscape. They tend to be concentrated near larger, more deeply incised watercourses and adjacent side valleys. The presence and distribution of caves and shelters suitable for human occupation, especially the larger caves, has undoubtedly affected prehistoric settlement patterns within the region.

Fort Leonard Wood occupies part of the broad dissected uplands between the Big Piney River and Roubidoux Creek (see Figure 1), which form parts of the eastern and western boundaries of the installation, respectively. Both of these streams flow generally northward and are tributaries of the Gasconade River, which is part of the Missouri River drainage. The divide between the Missouri and Mississippi basins lies at the head of these streams, about 40 km south and 25 km east of the installation. Most of the acreage of the installation lies on the upland interfluve between the Big Piney River and Roubidoux Creek. This zone is not as deeply dissected as the areas along the major watercourses and has distinctive geologic, soil and biotic characteristics.

The dominant rock series underlying the Fort Leonard Wood area are Ordovician-age dolomites and sandstones. Three Ordovician formations outcrop within the boundaries of the installation, and all dip slightly to the southwest. The Gasconade formation is the oldest, and it is exposed along the Big Piney River, portions of Roubidoux Creek and the lower reaches of several of the larger tributary drainages. The Gasconade formation is composed mainly of cherty dolomite, with a sandstone (Gunter) member near the base. The Gunter member does not outcrop at the surface within the boundaries of the installation. The Gasconade formation is conformably overlain by the Roubidoux formation, another cherty dolomite that also contains significant amounts of sandstone, quartzose sandstone (orthoquartzite) and some fine sediment partings. The Roubidoux formation is exposed at the surface along the floor of upper Roubidoux Creek and on most of the steep valley side slopes along the major and minor watercourses. The youngest formations are the almost-indistinguishable Jefferson City and Cotter formations, which outcrop as decomposed surface residuum on ridge crests in the central upland interfluve area (Anderson 1979; Ray 1985).

Larger tube and solution caves are often found within the Gasconade formation, which is composed of more massive dolomite with few mudstone and sandstone facies or beds within the formation. Both Miller and Sadie's caves are contained within the Gasconade formation. The overlying Roubidoux formation also contains numerous beds of sandstone, orthoquartzite and mudstone. As a consequence, the karstic features in the Roubidoux formation tend to be much smaller than those in the Gasconade formation.

All of these dolomite formations contain tabular and nodular chert of varying quality which was used for prehistoric manufacture of stone tools. The insoluble chert residuum often forms local gravel deposits in stream courses and cherty soil substrates in valley and side-slope settings. Ray (1985) has described the cherts found in these and other Ozark geologic formations in detail. Unfortunately, much of the chert from the Gasconade, Roubidoux and Jefferson City/Cotter formations is macroscopically indistinguishable in terms of its geologic formation of origin. All three formations contain oolitic and banded cherts and share a similar range of colors, textures and inclusions.

These characteristics of the various chert sources have several implications for prehistoric lithic resource studies and analyses of settlement systems in the Fort Leonard Wood area. Perhaps the most salient characteristic of the chert resources is their abundance. Residual chert forms the subsoil of most soil series mapped on side slopes, footslopes and small valley floodplains, and it is also commonly observed in gravel bars in the larger streams. Chert resources necessary for prehistoric stone tool manufacture are thus abundant and readily accessible almost anywhere on the installation. The quality and size of the chert raw material is variable, but all of the formations discussed above, and thus all of the residual chert sources in the area, potentially contain high-quality chert in medium- to large-sized cobbles. These conditions (chert abundance, chert accessibility and generally high chert quality) affect patterns of lithic resource procurement and those portions of the settlement system linked to procurement strategies. Under these conditions, it is highly likely that activities devoted to procurement of lithic resources will be embedded in other resource collection strategies and will not be the sole target of specific procurement sorties (see Binford 1979, 1982). It is therefore unlikely that sites devoted entirely to lithic quarry and workshop activities will be present. The activities normally associated with these kinds of sites will be included in other settlement types such as residential camps, field camps, or base camps (*sensu* Binford 1980).

A secondary effect of the chert resource characteristics noted above is that it is difficult for the lithic analyst to distinguish among the locally available and abundant chert types (Gasconade, Roubidoux and Jefferson City/Cotter). Differential use of these resources also will be difficult to determine. As a result, it is more informative to group the Ordovician cherts into a single local chert cluster and focus on identifying possible nonlocal lithic resources, the exploitation of which may be temporally or spatially significant. Such nonlocal resources include Burlington, Elsey and light-colored versions of Pierson and Reeds Spring cherts (undifferentiated Osagean cherts, [see Ray 1985]), available west of the installation, and St. Francois rhyolite and microcrystalline igneous rocks, available to the east. Nonlocal lithic raw materials were identified in the analyses when possible.

Four major soil associations are found in the installation, and these groups correlate closely with major physiographic boundaries (see Wolf 1989). In the flattest portion of the upland interfluve between the Big Piney River and Roubidoux Creek, the Lebanon-Plato association is found. These

silty soils are formed in loess deposits and have variable drainage characteristics. The more dissected upland interfluves and the summits and shoulders of larger ridges near the major streams are covered by soils of the Viraton-Clarksville-Doniphan association, composed of deep, well-drained silty to cherty soils. These soils formed in thin loess deposits overlying the cherty Jefferson City/Cotter dolomite residuum. The steep-sided valleys and bluffs in the major streams are covered by the Clarksville-Gepp association. These soils are thinner, well- to excessively drained and cherty to very cherty. Major stream valleys and some minor valleys are covered by soils of the Nolin-Huntington-Kickapoo association. These are deep, nearly level to gently sloping silty and loamy soils on floodplains and adjacent terraces.

The climate of the Fort Leonard Wood area can be characterized as typically midcontinental, with warm summers and cool winters (Wolf 1989). Average annual rainfall is about 100 cm, distributed relatively evenly throughout the year. The driest months tend to be August, September and October, and fire hazard increases greatly in the fall. The growing season generally ranges from 156 to 199 days, with the latest freeze occurring between 22 April and 9 May and the earliest freeze between 2 and 17 October of each year.

These climatic parameters were probably not stable throughout the Holocene. Evidence from pollen, gastropod and mammal sympatry studies in the Midwest indicates that climatic change, rather than stability, has characterized the Holocene. In general, early Holocene climate was cooler and probably wetter than the present regime. The botanical and faunal species present were modern in character, but their distribution may have been more patchy and fine grained than at present.

A major climatic shift during the middle Holocene has been recorded worldwide (Bryson et al. 1968; Deevey and Flint 1957; Wendland 1978). This period, known as the Atlantic Episode or Hypsithermal Interval, appears to involve a shift to drier and possibly warmer climatic conditions over much of the Midwest, and appears to last from about 8,500 to 4,000 years ago. The effects of the Hypsithermal are variable, depending on local physiographic and hydrologic conditions, but in general, several related landscape modifications appear to result from Hypsithermal impacts. Groundwater base levels appear to have dropped significantly in elevation, resulting in drying of many upland springs and seeps. There is evidence for a shift to less dense ground cover and more xeric vegetation, especially on better-drained slopes and uplands. There is evidence for spread of tall-grass prairie and mixed prairie-forest conditions far to the east during this time, resulting in establishment of what is now known as the Prairie Peninsula (Borchert 1950). Decreased vegetation cover and potential changes in seasonal precipitation patterns resulted in increased upland side-slope erosion and headward erosion of streams. The sediment eroded from uplands resulted in greater floodplain deposition and possibly in a shift in large river regimes from braided multiple channels to a single meandering high-amplitude channel dominated by overbank sheetwash deposition, development of backwater environments and deposition of massive amounts of redeposited alluvial silt in terrace formations. In the Fort Leonard Wood area, the Miller formation (T5 terrace) has been recognized as a mid-Holocene terrace that probably formed as a result of increased sedimentation during the Hypsithermal Interval (Albertson et al. 1995).

These changes in upland and alluvial vegetation, water tables, landforms, and associated faunal resources may have severely affected how humans used the landscape. In particular, there is evidence for abandonment of drier upland areas in favor of valley margin settings near abundant backwater and riverine resources (Ahler 1984; Brown and Vierra 1983; Jefferies and Butler 1982;

Warren 1990), increases in settlement size during the Hypsithermal (Ahler 1984), and changes in settlement strategy from residential mobility of small groups to more logistically organized systems oriented around base camps (Ahler 1984; Brown and Vierra 1983; Higgins 1990; Jefferies and Butler 1982). Specific effects of Hypsithermal climatic changes on human settlement in the Fort Leonard Wood area are unknown at this time, and constitute one of the major research topics that can be addressed through systematic excavation and analysis artifacts and paleoenvironmental data from mid-Holocene contexts.

During the late Holocene, the climate probably attained its present character, with relatively minor fluctuations recorded over the last 4,000 years. Floodplains became stabilized and upland vegetation attained its present character as a mesic forest. Again, changes in human use of the landscape may be correlated with the advent of the late Holocene climatic regime, but the specific nature of such changes has yet to be identified.

The Ozark Highlands region exhibits a wide diversity of plant communities, probably because of the topographic, geologic and hydrologic variability within the region (Steyermark 1963). Distinctive plant communities are found on rolling uplands, poorly drained uplands, steep slopes, bottomland terraces, floodplains, near springs and sinkholes, and in ravine bottoms. The heavily dissected nature of the region results in a finely grained mosaic of plant communities (see Harland Bartholomew and Associates 1992; Niquette et al. 1983). The U.S. Forest Service has published species composition and distribution lists for over 40 plant communities found in the adjacent Mark Twain National Forest (Miller 1981). Though there is considerable variability in local communities, overall the dominant plant communities in the region are oak-hickory and oak-pine forests with concomitant understory vegetation.

The present vegetation is substantially different from the prehistoric and early historic vegetation regime. Schoolcraft (1853) traveled across the Ozarks in 1818 and noted that large tracts in the Ozarks were either unforested or had stunted tree vegetation. This vegetation pattern may have been culturally promoted by Native Americans setting fires in the autumn to improve hunting conditions (Chapman 1946). An alternative explanation may be the development of nearly impermeable fragipan soils that inhibit root growth on flat and poorly drained uplands (Rafferty 1980). Regardless of the origin of this vegetation pattern, it was common to the region. An upland forest of this character would undoubtedly have affected prehistoric settlement and resource exploitation patterns. In other areas, large tracts of pine forest covered well-drained uplands, prairies were found on flat uplands, oak-hickory stands were present in high elevations, and cane thickets were abundant in bottomland settings.

The present vegetation is dominated by oak forests on uplands and side slopes, with white, post, black, and blackjack oaks most common. The valleys support a greater variety of trees, and sycamore, ash, cottonwood, sugar maple, walnut, butternut, hackberry, red oak, willow oak, and pecan are present in minor but consistent proportions. Niquette et al. (1983) noted the dominance of oak-hickory forests on Fort Leonard Wood, and described cedar glade communities in scattered upland settings. Niquette et al. (1983) also prepared a list of the common plant species found on the installation, their seasonality and potential economic and medicinal uses.

Faunal species in the Fort Leonard Wood area include those commonly encountered in the North American midcontinent. However, characteristics of local relief, vegetation and physiography

affect the distribution and abundance of faunal resources. The hydrology of the region is affected by the karstic landscape, and many of the larger side valleys hold only intermittent streams. However, the main watercourses of the Big Piney River and Roubidoux Creek are clear and cool, supporting a variety of fish and mussel species. The most common large mammal in the region is the white-tailed deer, and a variety of medium-sized mammals (raccoon, squirrel, mink, muskrat, beaver, red fox, gray fox, skunk, opossum, cottontail rabbit, and coyote) also would have been available to prehistoric inhabitants of the region. Terrestrial bird species that were of potential economic importance include wild turkey, bobwhite and prairie chicken. The Fort Leonard Wood area is not close to a major migratory route, so the seasonal fluctuations of aquatic bird species (ducks, geese, swans, etc.) probably had little effect on prehistoric subsistence patterns.

The botanical and faunal composition described above also would have been subject to fluctuations induced by short-term and long-term changes in climatic regimes. During the Hypsithermal Interval, the extensive oak barrens noted by Schoolcraft probably would have been an even more pronounced feature of the landscape. Hill prairies and even tall-grass prairie patches may have existed on xeric hill crests and slopes during the middle Holocene. The ravine slopes and bottomlands would have remained wooded, and the overall result would be to promote highly diverse vegetation and associated faunal communities in the Ozark region. If such changes occurred during the mid-Holocene, there should be signatures in the archaeological record of more xeric botanical or faunal species compositions associated with Middle Archaic components.

The natural physiographic area of the Salem Plateau region of the Ozark Highland has unique features and characteristics. These characteristics of the landscape, geology, hydrology, soils, flora, fauna, and climate interacted and in turn affected the nature, quantity and patterns of human occupation within the region. Chapman (1948a, 1975, 1980) utilized the natural divisions within Missouri to provide an environmental context with which to compare the development of long-term cultural traditions. There is often considerable continuity of cultural expressions through time within a given natural region, while differences among regions are often more pronounced. Chapman (1975) included the Fort Leonard Wood area in the Ozark Highland archaeological-physiographic region, with Pulaski County divided between the Lower Osage and Gasconade localities (drainages). Elaborating on the concept of combined cultural and natural areas within Missouri, Weston and Weichman (1987) utilize drainages as the major cultural/natural divisions of the state. Fort Leonard Wood is contained within the Gasconade Study Unit and includes portions of the Big Piney and Upper Gasconade watersheds.

These larger study units defined by Chapman and by Weston and Weichman provide physical contexts for the study and comparison of cultural developments on a regional scale. Within each study unit, developments and trends are assumed to be generally uniform. The nature and timing of specific cultural changes can be compared across regions to provide data on interregional trends, time-transgressive studies and pan-regional symbolism and exchange networks.

Within Fort Leonard Wood itself, smaller resource zones have been defined (Edging 1992) for the purpose of more effective cultural resource management. Cultural, drainage, physiographic, and soil series characteristics were used to divide Fort Leonard Wood into five broad zones, each with its corresponding cultural and natural features. All of the sites investigated here are within the Big Piney cultural resource zone, which includes the Big Piney River valley and adjacent terraces and bluffs in the northeast corner of the installation. A more focused description of the environment

of the Big Piney cultural resource zone and the Miller Cave Complex locale is provided in the next section.

Environment of the Miller Cave Complex Locale

The Miller Cave Complex consists of six sites (23PU2, 23PU235, 23PU254, 23PU255, 23PU288, and 23PU362) that are presumably temporally and/or functionally related. These sites lie within a distance of 400 m of each other and occupy the crest and southeast-facing bluff face of a large, dissected upland ridge in the northeast quadrant of Fort Leonard Wood (Figure 2).

The upland ridge that is the general landform context for all Miller Cave Complex sites is surrounded on the south, east and north sides by the Big Piney River valley. The ridge complex in general lies about 60 m above the elevation of the Big Piney River. The ridge has a very steep slope on its south and southeast faces, with vertical faces up to 25 m in height present in several locations on this aspect. The bluff base on the south side of the ridge has virtually no floodplain; the bluff drops down to a short, steep talus slope that forms a high north bank of the Big Piney River. The east end of the ridge is a steep but convex slope that meets the expanding floodplain and terrace system of the Big Piney River valley about 220 m east of the easternmost crest of the ridge. The north aspect of the ridge is dissected by a series of intermittent streams that form a series of deep draws and interfluvial ridge spurs. North of the ridge footslope, the broad valley of the Big Piney River forms a series of terraces that step down to meet the current stream bed.

The entire ridge system described above has not been surveyed for cultural resources. However, Moffat et al. (1989) surveyed timber sale tracts on eastern and western portions of the ridge system, and Niquette performed unsystematic survey in the Miller Cave area. These surveys resulted in location of the six sites that are part of the Miller Cave Complex and another potentially related site (23PU361) at the east end of the upland ridge. Two of the Miller Cave Complex sites (23PU288 and 23PU362) are large lithic scatters located on the ridge crest and eroded shoulder landform position. 23PU362 continues south outside the boundaries of Fort Leonard Wood for at least 40 m, while 23PU288 is contained entirely within the installation (Figure 2). Located between these upland open sites on a narrow ridge crest neck is site 23PU254, a disturbed cairn which is probably Late Woodland in age. The cave and rock shelter sites of the Miller Cave Complex are located on the southeast-facing bluff below 23PU288.

Just below the shoulder of the ridge is 23PU255, the Miller Petroglyphs. This site consists of a series of large, block rock falls contained within a low sandstone overhang that marks the lower boundary of the Roubidoux and underlying Gasconade dolomite formations. The southeast-facing, slanting surfaces of several of the rock-fall blocks have been engraved with a series of prehistoric rock art images. More recent historic additions to the rock faces are also present; these often take the form of names, initials, dates, and in some cases army unit affiliations.

The entrances to Miller Cave and Sadie's Cave lie about 13 m below the shoulder of the ridge crest. These two caves are at almost the same elevation, and are separated by about 80 m of undulating steep bluff face. Both of these caves are formed by solution and physical weathering of the massive Gasconade formation dolomite. The mouth of Sadie's Cave faces almost due east and is about 25 m south of the Miller Petroglyphs. The main opening of Miller Cave faces southeast,

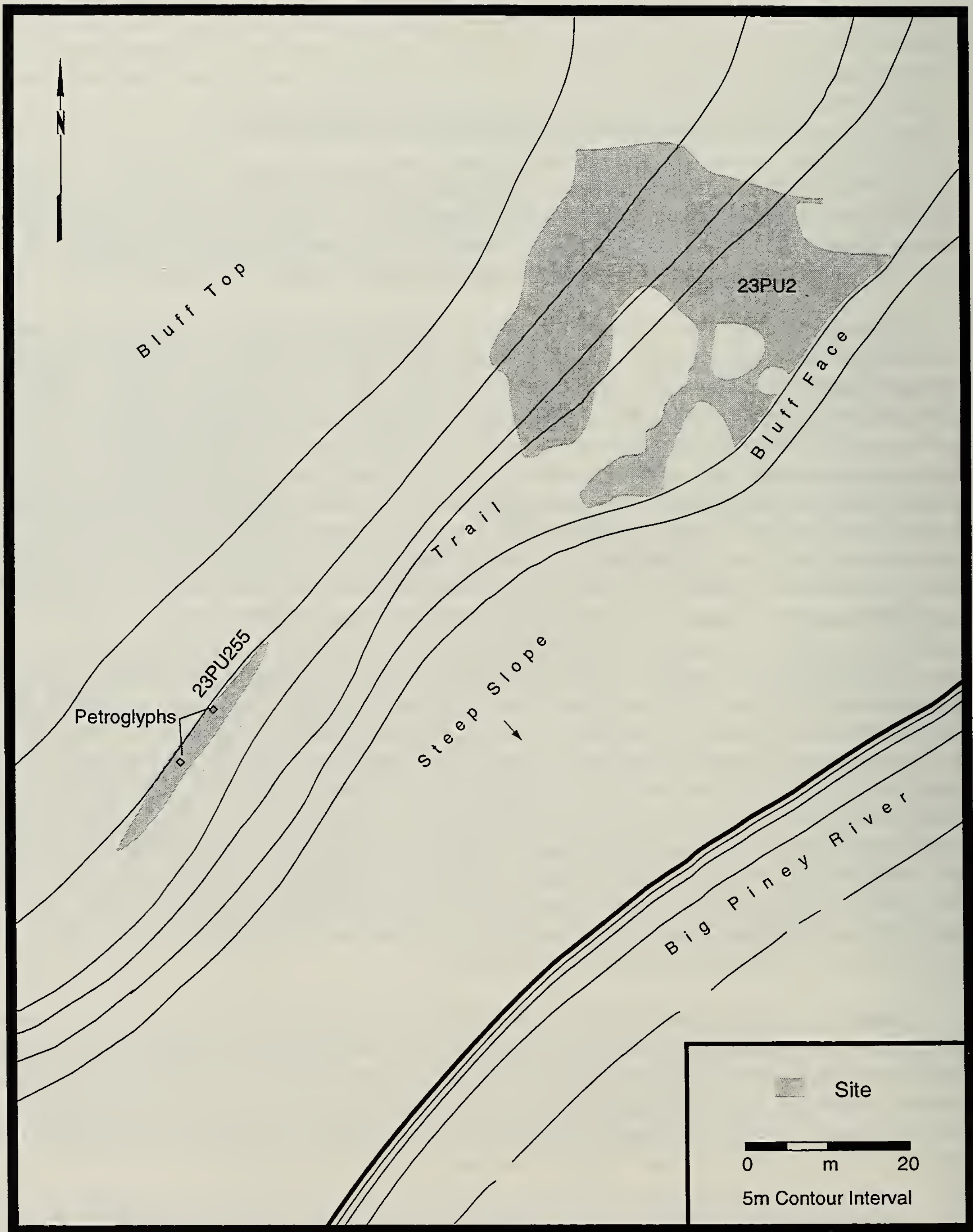


Figure 2. Physiographic Setting of the Miller Cave Complex.

but the best pedestrian approach to the cave is from the southwest, along an undulating shelf that follows the general contour of the bluff face between Sadie's and Miller caves. This undulating path enters Miller Cave through a large antechamber passage, which leads eventually through two small openings into the main chamber of the cave. The internal configuration and features of Miller Cave are discussed in more detail in Chapter 5.

All three sites investigated here are on the southeast-facing upper bluff face: Figure 3 shows the general topographic contexts and relationships between these three sites. The physiography and topography of the bluff face is important to understanding the formation and sedimentation processes associated with Sadie's Cave, and to.a lesser extent, Miller Cave. The steep southeast-facing slope contains a series of bedrock shelves that are generally level in elevation, forming a series of steps down the bluff face that run parallel to the contour lines. However, these shelves have been eroded in some places, creating shallow notches or small draws on the bluff face. In other areas, sediment has washed down the bluff face and accumulated on the flatter shelf surfaces, forming a series of sediment cones. The end result of these processes is that what started as relatively flat bedrock shelves on the bluff face have been transformed into undulating surfaces that consist of alternating small erosional features and colluvial sediment cones. Vertical or near-vertical bluff face segments up to 5 m high separate shelf surfaces from each other. The undulating surfaces now form the natural pathways that allow easy foot travel up, down and across the bluff face.

One of the small colluvial sediment cones that accumulated on the bluff face shelves is the primary source of Holocene sediment for Sadie's Cave. This sediment cone formed at the base of a nearly vertical bluff face segment located between the southwest end of 23PU255 and the mouth of Sadie's Cave. Sediment accumulated in a colluvial cone whose apex is just north of the mouth of Sadie's Cave. The expanding sediment cone built mainly southward and westward (downslope), partially filling the mouth and eastern third of the interior of Sadie's Cave. Artifacts associated with episodes of human occupation that took place on the aggrading sediment cone surface either within the cave or near the cave drip line were incorporated into the aggrading colluvial sediment cone. This formation process resulted in accumulation of at least 1.7 m of sediment near the cave mouth and preservation of stratified cultural deposits and associated Holocene ecofacts.

A similar accumulation of colluvial sediments probably occurred in the entryway antechamber of Miller Cave. This portion of Miller Cave has a sloping floor that includes cultural and natural accumulation of sediment. The southwest opening of this antechamber is higher in elevation and is essentially the apex of a sediment cone that has built upward in the entryway mouth.

Soils in the Miller Cave Complex locale consist of Doniphan very cherty silt loam with 3–9 percent slope on the upland ridge crest and the Gepp-Rock outcrop complex with 35–60 percent slopes on the side slopes. The Doniphan series was formed in thin loess overlying and partially incorporating cherty residuum. The Gepp-Rock outcrop series is characterized by deep cherty silt loams that formed in redeposited sediment on top of cherty residuum (Gepp series), interspersed with rock outcrops (Wolf 1989). The soils in the immediate area of the Miller Cave Complex are consistent with those mapped on the county soil survey.

The environment and soils described above support a vegetation regime composed mainly of oak forest. In areas where the Gepp soils are thin and dolomite bedrock is close to the surface, hill-prairie environments may develop. Hill prairies support a mixture of eastern red cedar and native

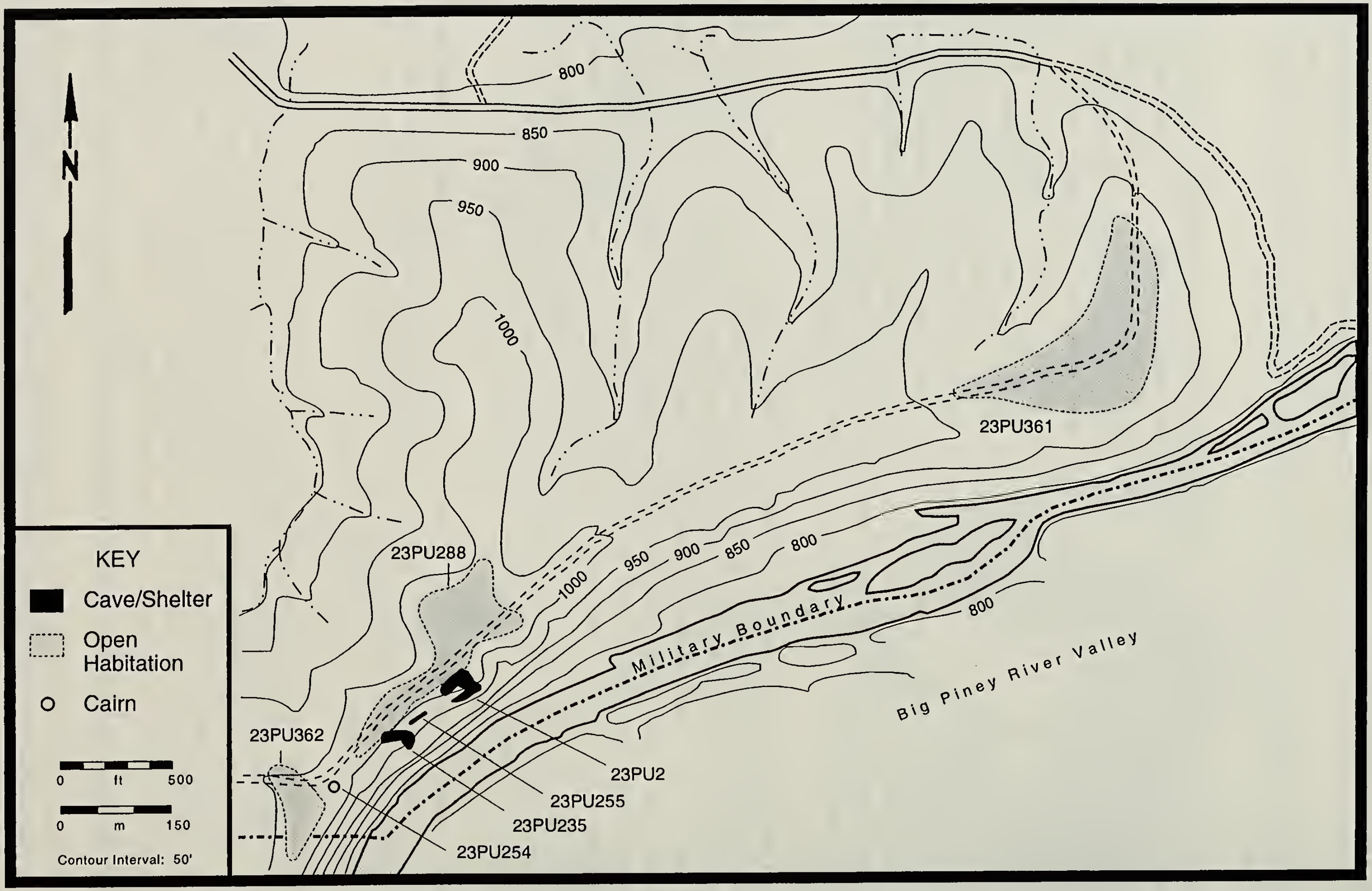


Figure 3. General Topographic Context of Miller Cave, Miller Petroglyphs and Sadie's Cave.

prairie grasses as ground cover, and this vegetation in turn supports a more xeric faunal regime. In the Miller Cave Complex locale, a narrow band of hill-prairie vegetation ranging from 5 to 20 m in width is presently found at the shoulder of the upland ridge crest. The Miller Petroglyph site is directly within this narrow band of hill-prairie vegetation. Upslope from the hill prairie, upland oak forest dominates the vegetation. Downslope from the band of hill prairie, forest cover includes a mixture of mesic species such as oaks, hickories, catalpa, ash, and walnut. The ground cover at the bluff base, on the north bank of the Big Piney River, includes more aquatic species such as sycamore, elm and hackberry, as well as the dominant oaks and hickories.

It is clear from the above discussion that, at the present time, there is a great deal of physiographic and vegetation community diversity expressed within a short distance of the Miller Cave Complex. It is likely that similar ecological diversity existed in the prehistoric environment as well, but the precise nature of the paleoenvironment remains unclear at this time. While it is reasonable to expect that in general, the present environmental conditions prevailed throughout the late Holocene (during the last 4,000 years), it is unlikely that present conditions provide an accurate analog for paleoclimatic and paleoenvironmental conditions that prevailed during the middle and early Holocene. During the warmer and drier Hypsithermal Interval (Middle Archaic period), the hill prairies may have expanded to cover much more of the upland slopes and ridge crest that is evident at present. During the early Holocene (Early Archaic period), available regional climatic data suggest climatic conditions that were cooler and wetter than the modern analog (Baerreis and Theler 1981; Theler and Baerreis 1991; Wood and McMillan 1976). The associated vegetation and faunal regimes are difficult to predict, and they may have no modern analogs that are relevant for comparison. Providing a more empirically based description of local early and mid-Holocene paleoenvironmental conditions is one of the major research goals that can be addressed through analysis of stratified deposits such as those present in Miller and Sadie's caves.

The aspects of the environmental setting discussed above have potentially important bearing on the interpretations of the cultural components represented at the Miller Cave Complex sites. Before these implications are developed fully in terms of general and site-specific research goals, it is necessary to provide a cultural/historical context for the project and the specific sites investigated here. This and related topics are discussed in detail in the next chapter.

CHAPTER 3
CULTURAL CONTEXT

This chapter presents a general framework of prehistoric and historic cultural development in the Ozark region and Fort Leonard Wood in particular. These data are extracted and summarized from major regional archaeological syntheses, especially Chapman (1975, 1980), Douthit et al. (1979), Wright (1987), and the prehistoric overview presented in Harland Bartholomew and Associates (1992). Information specific to the Gasconade drainage has been derived from syntheses by McMillan (1965) and Reeder (1988). A later section provides an overview and critique of previous work conducted at Fort Leonard Wood. The discussion also draws upon previous PSAP reports (Ahler and McDowell 1993; Ahler et al. 1995). These data provide an interpretive framework for evaluating previous work conducted at the Miller Cave Complex sites and developing site-specific research goals, which are presented on a site-by-site basis in Chapters 5, 6 and 7.

General Cultural/Historical Framework for Fort Leonard Wood

The regional cultural sequence for Missouri is divided into six major periods, some of which are subdivided into early, middle or late subperiods (Chapman 1975, 1980). Table 1 shows temporal ranges for these cultural periods (adapted from Chapman [1975, 1980]; McMillan [1965]; Reeder [1988]). General cultural developmental trends that transcend time periods include increases through time in 1) population density; 2) population aggregation; 3) focus on locally abundant food resources; 4) subsistence importance of cultivated plants; 5) regionalization of cultural traditions; 6) social and political complexity; and 7) importance of pan-regional ideological and symbolic/cosmological integrative systems. Specific cultural or technological developments are often shared over a wide region and serve as broad area horizon markers. The Ozarks region also has its own local expression of these trends, and specific attributes are briefly discussed when appropriate.

Early Man Period (more than 14,000 years ago)

This is the most poorly understood time period in Missouri, and many archaeologists debate its existence. Criteria for positive recognition of sites of this period still need to be established. Recovery of extinct fauna in association with crude stone tools has been proposed, but recent evidence from Paleoindian period sites indicates that the quality of stone tool workmanship was highly variable. No Early Man sites have been reported from the Gasconade drainage, though Chapman (1975) indicates that river terraces and caves/rock shelters are most likely to provide unequivocal evidence of sites of this age.

Paleoindian Period (14,000 to 10,500 years ago)

The Paleoindian period represents the earliest unequivocal occupation of the New World by people migrating from northern Asia across the exposed land mass now covered by the Bering Strait. This period is well-documented in portions of the United States, especially the Great Plains, where a series of morphologically and technologically distinct projectile point/knife or hafted biface forms are associated with broad regional traditions. These point styles represent lanceolate forms with long, narrow flakes removed from the base, forming a characteristic channel or flute that facilitated

Table 1. Regional Temporal Periods and Local Cultural Manifestations in the Gasconade Drainage and Fort Leonard Wood Area.

Major Temporal Period	Local Manifestation
Historic (A.D. 1700–present)	Euroamerican settlements
Late Mississippian (A.D. 1450–1700)	Late Maramec Spring Phase (A.D. 900–1700)
Early Mississippian (A.D. 900–1450)	
Late Woodland (A.D. 400–900)	Early Maramec Spring Phase (A.D. 400–900)
Middle Woodland (500 B.C.–A.D. 400)	Spring Creek Complex (?) (A.D. 1–400 ?)
Early Woodland (1000–500 B.C.)	No defined local manifestation
Late Archaic (3000–1000 B.C.)	Sedalia Phase (?) or James River Complex (3000–1000 B.C.)
Middle Archaic (5000–3000 B.C.)	No defined local manifestation
Early Archaic (7800–5000 B.C.)	Tick Creek Complex (?)
Dalton (8500–7800 B.C.)	Dalton Complex
Paleoindian (12,000–8500 B.C.)	No defined local manifestation
Early Man (pre-12,000 B.C.)	No defined local manifestation

hafting onto bone or wood handles. Many of the more refined specimens are made from high-quality, nonlocal chert, indicating a high degree of mobility and probably well-developed exchange networks. Paleoindian groups are believed to have been organized into small, highly mobile groups integrated politically and socially into egalitarian bands. Settlement systems were apparently based on residential mobility. Subsistence systems probably were highly generalized, exploiting locally available megafauna and a variety of smaller terrestrial mammal species as well. Patterns of plant use for Paleoindian groups is poorly documented.

No major Paleoindian sites are reported for the Gasconade drainage, and no sites of this time period are reported from Fort Leonard Wood. A few isolated surface finds of Paleoindian points are reported in Chapman (1975) for the Gasconade drainage, though none are from Pulaski County. Caves, rock shelters and perched terrace remnants are the most likely landforms on which to find Paleoindian sites with intact stratigraphy.

Dalton Period (10,500 to 9,800 years ago)

The transition from late Pleistocene to Holocene environment brought about extinctions of megafauna across North America and development of modern biotic regimes. This transition has an apparently short-lived but distinct archaeological expression in the Dalton culture (see Goodyear 1982). This manifestation was originally defined in northern Arkansas and southern Missouri (Goodyear 1974; Morse 1973; Morse and Goodyear 1973; Price and Krakker 1975) and is characterized by a chipped-stone tool assemblage that includes the distinctive lanceolate, nonfluted Dalton projectile point and its variants, chipped-stone adzes and spurred end scrapers. Dalton period settlement patterns and systems have been examined in detail in the southern Ozarks and Missouri Bootheel region (Morse 1975, 1977; Schiffer 1975). Settlement patterns apparently include a variety of site types, including base camps occupied for long periods of time, resource extraction camps, smaller generalized residential camps, and special-purpose cemetery sites (Goodyear 1974). The presence of this variety of site types in a single settlement system suggests that settlement was more logistically organized (*sensu* Binford 1980), perhaps oriented around exploitation of seasonally abundant aquatic resources by larger population aggregates. Unfortunately, recovery of actual subsistence remains (faunal or botanical) from Dalton sites is rare, and these settlement models remain largely untested.

Several important Dalton components are found in Missouri, including stratified deposits at Rodgers Shelter (Kay 1980), Graham Cave (Klippel 1971; Logan 1952), and Arnold- Research Cave (Shippee 1966). All of these sites yielded fully modern faunal assemblages. Two Dalton sites have been reported from Fort Leonard Wood; 23PU190 (Niquette et al. 1983) and 23PU494 (Ahler and McDowell 1993) are located in the Interior Uplands resource zone. In addition, a Dalton point was recovered from Sadie's Cave during Phase II excavations (Ahler et al. 1995); radiocarbon assays, however, indicate that this point was redeposited out of its original context of manufacture and use.

Early Archaic Period (9,800 to 7,000 years ago)

Sites assigned to this period are more common than for earlier periods. Artifacts diagnostic of the Early Archaic period include a variety of lanceolate (Rice Lanceolate), contracting stemmed (Hidden Valley), straight-stemmed (Hardin), side-notched (Graham Cave), corner-notched (Thebes, St. Charles, Kirk, Jakie stemmed) and bifurcate base (Rice Lobed and LeCroy) hafted bifaces that

represent both temporal and functional variability. The Ozark highland region contains a number of sites, mostly caves/rock shelters, with significant Early Archaic components. These include Jakie Shelter, the Rice site, and Standlee Shelter (Table Rock Reservoir), Rodgers Shelter (Pomme de Terre drainage), and Tick Creek Cave (Gasconade drainage). The suite of hafted bifaces listed above compares favorably with many of the hafted bifaces described by Roberts (1965) and McMillan (1965) in their original description of the Early Archaic Tick Creek Complex. However, Chapman (1975) points out that Middle and Late Archaic materials represented by later point types (Stone Square Stem and large sided-notched points) may also have been included in the original Tick Creek Complex assemblage. Based on work in other portions of the Midwest, it is likely that the temporal and functional variability represented by the Tick Creek Complex can be separated into more restricted phases and components through excavation of stratified sites.

Early Archaic sites are usually small and scattered on upland and higher stream terrace settings. These attributes suggest that populations were composed largely of small, highly mobile residential groups organized into egalitarian bands. Local populations may have coalesced periodically into larger population aggregates to take advantage of seasonally abundant resources, but these were probably episodic events of short duration. Early Archaic subsistence may have included more plant resources than earlier periods, but this may also be a factor of preservation.

Several sites at Fort Leonard Wood and the nearby Houston-Rolla Ranger District have yielded Early Archaic points. These include 23PU229 (an upland lithic scatter), 23PU304 (a floodplain lithic scatter), 23PH231 (a multicomponent upland lithic scatter), and 23PU210 (a disturbed stratified cave). At the Kofahl Tract on the Big Piney River upstream from Fort Leonard Wood, four sites yielded Early Archaic points (Fraser et al. 1981). Six Early Archaic sites were identified in the Big Piney and Upper Roubidoux resource zones through recent surveys by the University of Illinois (Ahler and McDowell 1993).

Middle Archaic Period (7,000 to 5,000 years ago)

In the Midwest in general, this cultural period is marked by a shift in settlement toward major river valley margins and increasing use of aquatic resources by larger population aggregates (Ahler 1984; Brown and Vierra 1983; Jefferies and Butler 1982; Styles 1986). Hafted bifaces characteristic of this period include large and small side-notched points (Godar, Matanzas, Raddatz, and Big Sandy), and small corner-notched points (Jakie stemmed) in the early part of the period and medium to large corner-notched/expanding stem points (Big Creek, Saratoga cluster, Table Rock Stemmed) and large straight-stem points (Stone Square Stem, Smith/Eva, and Karnak) in the later part of the period. No specific Middle Archaic phase or assemblage complex has been defined for the Gasconade drainage, though McMillan (1965) described several points characteristic of a Middle to Late Archaic complex. New tool types such as the fully grooved axe and ground-stone celt are added to the technological assemblage during this period. Ozark region sites with major Middle Archaic occupations include Rodgers Shelter, Jakie Shelter, the Rice site, Standlee Shelter, and possibly Tick Creek Cave.

Based on the recovery of only moderate numbers of Middle Archaic artifacts from sites in the Gasconade drainage (Tick Creek Cave, Goat Bluff Cave, and Miller Cave [McMillan 1965; Roberts 1965]), Chapman (1975) proposed that the Gasconade drainage was used mainly for hunting during the Middle Archaic by populations with base camps located outside the drainage. This

conclusion may be an artifact of sampling, since Middle Archaic sites apparently are fairly numerous at Fort Leonard Wood. At least 23 sites have yielded Middle Archaic materials (Ahler and McDowell 1993; Markman and Baumann 1993; Moffat et al. 1989; Niquette 1984; Niquette et al. 1983).

Examination of Middle Archaic settlement patterns and systems at Fort Leonard Wood will have implications for the broader region. The settlement patterns noted above for the Middle Archaic period are derived from studies that focused mainly on sites in or near the Mississippi and Illinois river valleys. In part, changes in settlement systems during this period are probably a result of the impact of the Hypsithermal climatic interval on local upland and riverine resource distributions. As noted in Chapter 2, specific local effects of the Hypsithermal are highly variable, and it remains to be seen whether the same changes in settlement systems will be documented in the largely upland landscape of Fort Leonard Wood.

McMillan and Klippel (1981) proposed that the Hypsithermal Interval would tend to increase oak mast yields in the central and eastern Ozarks, resulting in greater deer and turkey populations. These factors should promote greater use of the area by humans, and this should be reflected in the archaeological record as increased intensity of site use and more focused use of locally abundant food resources during the Middle Archaic period. Paleoenvironmental research at Fort Leonard Wood, especially excavation of stratified cave/rock shelter sites with bone and plant preservation such as those present in Miller and Sadie's caves, provides an ideal vehicle through which to test models of Middle Archaic cultural responses to climatic changes.

Late Archaic Period (5,000 to 3,000 years ago)

The Late Archaic period in the Ozarks is marked by continued manufacture of many projectile point styles that were in use at the end of the Middle Archaic period. Large side-notched types seem to drop out of the assemblage, but the medium and large corner-notched/ expanding stem points apparently continue to be made into the first half of the Late Archaic period. New hafted biface types are also added to the assemblage including corner-notched (e.g., Afton), stemmed (Burkett, Etley) and lanceolate (Sedalia, Wadlow) types. Distinctive nonprojectile point tool types include the triangular, unifacial Clear Fork gouge (possibly used as a woodworking tool) and the rectanguloid, bifacial Sedalia Digger. A greater variety of ground-stone tools (3/4-groove axes, celts, pestles, manos, bannerstones, plummets) is also present in Late Archaic assemblages, and many of these tools are associated with plant processing. Increased reliance on plants is supported by recovery of some of the earliest domesticated squash and gourd remains in the eastern United States from Late Archaic contexts at Phillips Spring (Chomko 1978; Kay et al. 1980).

Chapman maintains that several of these point types, and perhaps the entire Late Archaic adaptive strategy, persist into the Woodland period in the Ozark region. In fact, most of the projectile point types listed above are found in either poorly dated contexts or mixed deposits containing both Woodland and Late Archaic cultural materials. The absence of data on specific point styles recovered from well-dated stratigraphic contexts poses a serious drawback to basic cultural-historical interpretations in the Ozarks. Several point types apparently persist for long periods of time, and cultural affiliation for these artifacts is most conservatively described as "Late Archaic to Woodland". Documentation of specific point types in dated stratigraphic contexts is needed to build and refine regional Late Archaic and Woodland chronology.

Two local Late Archaic cultural manifestations have been proposed for portions of the Ozark highland. The James River complex was defined largely from assemblages in the Table Rock Reservoir (Springfield Plateau portion of the Ozarks), and includes Afton, Smith Basal Notched, Stone Square Stem and Table Rock point types. The Sedalia Complex is centered in the lower Missouri and Osage drainages, and includes Etley Stemmed and Sedalia Lanceolate point types (Chapman 1975). Apparently, the Fort Leonard Wood Late Archaic sites lack the artifact signatures that are traditionally associated with the Sedalia complex, though the geographic location of the installation makes it less likely to be associated with the James River complex, which is a southwest Missouri manifestation. Late Archaic components are common on the installation, with at least 20 sites having components assigned to this period (Ahler and McDowell 1993; Markman and Baumann 1993; Moffat et al. 1989; Niquette 1984; Niquette et al. 1983). However, the vast majority of these sites are multicomponent, and additional evaluation will be required before specific components and artifact assemblages are isolated.

Early Woodland Period (3,000 to 2,000 years ago)

Traditionally, the beginning of the Woodland Period is marked by the appearance of pottery in archaeological assemblages. In many areas, subsistence, settlement and social organization remain essentially unchanged from Late Archaic patterns except for the addition of ceramics to the technological base (see Chapman 1980; Farnsworth and Emerson 1986). Distinctive projectile point styles unique to the Early Woodland period are few in number, and a local expression of Early Woodland adaptation has not been defined in the Gasconade drainage. In addition, pottery types indicative of Early Woodland ceramic technology have not been described in the region. Chapman (1980) has maintained that Late Archaic adaptations, including many of the projectile point styles archaeologists use to identify temporal periods, were maintained in the Ozarks well into first millennium A.D., which would include the Early and Middle Woodland periods. Clearly, archaeological signatures of both Early and Middle Woodland periods are ephemeral and unclear in the Ozark region. Defining assemblage characteristics of the Early Woodland period and differentiating this period from Late Archaic adaptations constitute one of the main culture-historical goals of Fort Leonard Wood research.

Niquette et al. (1983) and Niquette (1984) list nine sites assigned to the Early Woodland period. However, these assignments are based on recovery of Gary and Langtry points, which have a long history of manufacture (at least 3,500 to 1,500 years ago). It may be more accurate to assign sites with these points to a generalized Woodland temporal affiliation rather than to a specific time period.

Middle Woodland Period (2,500 to 1,600 years ago)

As with the Early Woodland period, a local Middle Woodland manifestation has not yet been defined for the Ozark region. If the distinctive ceramic styles indicative of participation in the Middle Woodland Hopewell interregional ideological and exchange networks are absent in assemblages, local Middle Woodland expressions are difficult to identify. Other artifact signatures that have been traditionally used as markers of Middle Woodland temporal affiliation include distinctive Snyders corner-notched projectile points (often reworked into hafted scrapers) and small lamellar blades (Montet-White 1968). Neither of these lithic Middle Woodland indicators is common in the Gasconade drainage. Thin, grit-tempered pottery similar to Middle Woodland utilitarian wares

from other parts of the Midwest has been identified in low frequencies at a few sites in the Gasconade drainage, including sites on Fort Leonard Wood (23PU152 and 23PU210 [Niquette et al. 1983] and 23PU265). A well-defined Middle Woodland ceramic expression is certainly elusive in the Gasconade drainage.

The lack of evidence for participation in panregional exchange networks has been interpreted by Chapman (1980) and McMillan (1965) as evidence for an absence of permanent Middle Woodland settlement in the Gasconade drainage, or even for general abandonment of the region. Based on work at the Feeler site, Reeder (1982, 1988) defined a Middle Woodland artifact assemblage known as the Spring Creek Complex, with proposed temporal boundaries of A.D. 1–400. Reeder offered an alternative interpretation of Middle Woodland adaptation that included a resident population with an essentially aceramic technological base identified by Kings and Snyders corner-notched projectile points. Recent test excavations at Fort Leonard Wood (Ahler et al. 1995) resulted in identification of at least three sites (23PU235, 23PU249 and 23PU265) with Middle Woodland-age components in intact stratigraphic contexts. All of these sites produced strata that date between about 1,600 and 2,100 years ago, and all of these strata contain essentially aceramic assemblages. These findings partially support Reeder's interpretation of the Spring Creek Complex. However, this support must be tempered with the knowledge that all of these components are derived from cave sites. The range of activities that took place in caves may be somewhat specialized compared to open-air general habitation sites; the cave site assemblages may not include ceramic artifacts.

It is unclear whether other Middle Woodland cultural patterns common in the Midwest (such as intensive use of native cultigens, two-level settlement hierarchy or social differentiation in mortuary practices) are expressed in any local Middle Woodland period manifestation. More research is needed to define the local Middle Woodland cultural manifestation and its degree of participation in panregional cultural systems.

Late Woodland Period (1,600 to 1,100 years ago) and Mississippian Period (1,100 to 300 years ago)

Late Woodland culture is well-expressed in the Midwest and in the Gasconade drainage. Locally, Late Woodland sites are denoted by the presence of cordmarked or plain dolomite-tempered ceramics dominated by jar forms. Diagnostic Late Woodland lithic artifacts include Kings corner-notched and Rice side-notched in the early part of the period and a variety of small arrow points (Crisp Ovate, Sequoyah, Scallorn, Hayes, etc.) in the later part of the period. In addition, there appears to be some degree of social differentiation expressed in mortuary programs—some individuals are interred in rock cairns, usually located on upland prominences overlooking broad stream valleys. The local Late Woodland manifestation is the Maramec Spring Focus (Marshall 1958, 1965), which has been subsequently divided into early and late Maramec Spring phases (Reeder 1988).

In the major river valleys of the Midwest and Southeast, the Late Woodland period is followed by a period of cultural and social florescence known as Mississippian. This period is marked by technological changes (shell-tempered pottery, bow and arrow) and changes in social integration and complexity (hierarchical settlement systems, large town-and-mound complexes; elaborate elite burial ceremonialism; differential access to subsistence resources). The Gasconade drainage apparently does not contain a well-developed Mississippian expression. Instead, the Maramec Spring Late Woodland culture continues, with the addition of a few elements indicative of

interaction with Mississippian peoples or peripheral participation in Mississippian ceremonial/ideological/exchange systems. The latter include occasional shell-tempered pottery, rare incising and punctation on ceramic vessels, and occasional recovery of exotic marine shell artifacts.

The Late Woodland period is the best documented period at Fort Leonard Wood and in the Gasconade drainage in general. Maramec Spring Phase settlement patterns include extensive villages in both valley and upland ridge crest settings, smaller hamlets and extractive camps, and extensive use of caves and rock shelters, possibly for specialized activities. Maramec Spring Phase sites are common in the Gasconade drainage and on Fort Leonard Wood in particular. Maramec Spring occupations (either early or late) have been identified at over 35 sites on Fort Leonard Wood (Ahler and McDowell 1993; Markman and Baumann 1993; Moffat et al. 1989; Niquette 1984; Niquette et al. 1983); ceramics were recovered from about half of these sites. Of a sample of 15 sites on Fort Leonard Wood recently subjected to Phase II NRHP evaluation (Ahler et al. 1995), Late Woodland components were identified at 13 sites. Because of the abundance of Late Woodland sites and the variety of site types and settings, investigation of the settlement and subsistence systems of the early and late Maramec Spring phases is an important long-term research project with implications for regional and interregional archaeological studies.

No local Mississippian manifestation has been clearly defined for the Fort Leonard Wood area. While Mississippian influences are apparently represented in some of the late Maramec Spring Phase ceramic assemblages, the degree of local interaction and participation in the larger Mississippian cultural system has not been defined.

Historic Period (300 years ago to present)

Smith (1993) provides an excellent summary and developmental context for the historic period in the Ozarks and at Fort Leonard Wood in particular. The following summary is extracted from his report; additional information is found in McGrath and Ray (1987).

In the eighteenth century, Pulaski County and the Fort Leonard Wood area were inhabited by the Osage Native American tribe, who used the area mainly for hunting rather than permanent habitation. In the late eighteenth and early nineteenth centuries the area also came to be populated by small numbers of Kickapoo, Delaware, Shawnee, and Cherokee, who had been driven westward by expanding Euroamerican and African-American settlement. All remnants of these tribes had been removed from Missouri by about 1830.

The first non-Native American settlers in the region were French explorers and lead miners who began traveling through the Ozarks as early as 1719. French settlement in the Ozarks was sparse and its effect on the landscape and archaeological record is minimal. American settlement of the area began around 1800 with the occupation of the area by scattered pioneer hunters, subsistence farmers and lumbermen, with most settlements located in the larger stream valleys. Gradually, more people arrived in the area, but the rugged topography kept population levels low. Most pioneers in the early nineteenth century bypassed the Ozarks in favor of the more abundant and fertile farm territories along major river valleys such as the Missouri, White and Arkansas.

Pulaski County was organized in 1833, and increasing numbers of permanent settlers arrived from eastern states. The settlement pattern appears to have been one of detached residences or

farmsteads and hamlets scattered along rivers and larger creeks. Actual farming was done in small floodplain plots, with house locations on valley margin footslopes or side slopes. Lumbering, hunting and subsistence farming remained the major occupations. By 1860, population levels were rising, road systems had been constructed, and railroads were helping to develop the lumber industry in the area. Civil War actions in the county resulted in abandonment of many rural farmsteads and general economic decline.

Repopulation of the area began again after the Civil War, but the landscape and farmsteads had been deleteriously affected by abandonment. Fueled by construction of a railroad through the county in 1867, population increased greatly and economic concerns began to focus on rural industries, especially lumbering. Railroads also brought material goods into the area, promoting a change from self-sufficient farming/hunting/lumbering households to more consumer-oriented households linked to and more dependent on outside markets and manufactories. Cross tie production was the major industry for rural upland settlers without access to good river bottom farmland. This occupation was the prevalent rural industry in the county from the 1870s through World War I.

The economic and cultural prosperity of the area reached its peak around 1910. Soon after that, overcutting of lumber resources and soil erosion brought economic decline and depopulation to southern Pulaski County. The area also was strongly affected by the Great Depression. The largely self-sufficient farmers and hunters that dominated the Ozark population of the nineteenth century had given way to larger consumer and producer communities with increasingly intimate ties to regional and national economies. Population peaked around 1910 and remained generally steady until about 1940. Several small crossroad communities located within the boundaries of Fort Leonard Wood had been established in the nineteenth century and continued to flourish during this period. The largest and most economically important was Bloodland; other trading communities included Big Piney, Cookville, Bailey, Moab, Wharton, Wildwood and Tribune.

The 1930s witnessed the increasing emergence of the Federal government as an economic and social factor in Pulaski County. Various projects sponsored by the U.S. Department of Agriculture and the Civilian Conservation Corps directly affected economics and population in the Fort Leonard Wood area. The CCC had established numerous camps within the Mark Twain National Forest and the present Fort Leonard Wood boundary.

In 1940, the U.S. Army announced the planned purchase of 65,000 acres in southern Pulaski County. This created an immediate massive influx of laborers and support personnel into the area. As many as 30,775 workers camped within a 50-mile radius of the fort (Mayes 1941, in Smith 1993). The economic and social transformation of the area has had a lasting effect on local communities. The resident populations of Bloodland and other small communities located within the fort boundaries were displaced, and the former hamlets were razed. Small communities outside the fort (Waynesville, St. Robert) witnessed unprecedented economic and population growth. After World War II, population in the area and military use of the base fluctuated greatly until the base was given permanent status in 1965.

Previous Investigations at Fort Leonard Wood

The following summary has been drawn mainly from earlier reports (Ahler and McDowell 1993; Ahler et al. 1995; Baumann and Markman 1993; Markman and Baumann 1993; Moffat et al. 1989; Niquette 1984; Niquette et al. 1983) and a dissertation (Reeder 1988) of work conducted at Fort Leonard Wood and in adjacent areas. Synopses of these previous investigations are presented below. The discussion is divided into a general discussion of previous work in the region, a discussion and review of work conducted specifically at Fort Leonard Wood, and a more specific discussion of former projects in the Miller Cave Complex locale. Because the results of work done at individual sites in the Miller Cave Complex are intimately tied to development of site-specific research goals, these topics will be developed and discussed in detail in Chapters 5, 6 and 7, which are devoted to the sites investigated here.

Previous Work in the Region

The first reference to archaeological sites in the region around Fort Leonard Wood was made early in the nineteenth century by Beck (1975[1823]), who described the remains of a prehistoric village in Pulaski County. Later, in a history of Missouri, Conant (1879) noted the presence of prehistoric remains in caves, rock shelters and mounds in the Gasconade area. This work included the first report on an excavation in this area, a cave site containing human burials. The Goodspeed Publishing Company (1974[1889]) later described mounds also located in Pulaski County. Both Beck and the Goodspeed Publishing Company made reference to stone walls, and the latter noted that some had burials beneath them. Later discussions of mounds, rock cairns, villages, campsites, and caves and rock shelters were made by Bushnell (1904) and Houck (1908).

The first scientific investigations in central Missouri were made by Fowke in the early twentieth century (Fowke 1922, 1928). Several of the sites he visited are located on Fort Leonard Wood; namely, Kerr Cave, the Davis caves and Miller Cave. The latter produced artifacts assignable to the Early Archaic through Late Woodland periods, and possibly into the Mississippian period. Fowke, unfortunately, was interested mainly in lithic artifacts and hoped to demonstrate a relationship between early American cultures and the European Paleolithic, ultimately ignoring most other types of artifacts. Later, Fenenga (1938) reported on the ceramics from six caves, including four in Pulaski County. He developed a ceramic classification from the excavated materials, finding two ceramic types—one grit-tempered and one shell-tempered. These were associated with the Woodland and Mississippian cultures, respectively.

By the 1940s, little work had been done in the region, and Chapman (1946, 1947, 1948a, 1948b), who was developing a statewide cultural sequence, was faced with a general lack of data. There was little evidence of Paleoindian or Archaic occupation, but he was able to identify a "Late Woodland Highland Aspect" for the area.

Beginning in the 1950s, some of the first investigations driven by historic preservation concerns were carried out in the region. Shippee began a survey of the proposed Richland Reservoir in 1957 (Anonymous 1957; McMillan 1965), and Marshall (1958, 1965, 1966) worked on the Meramec River and near the headwaters of the Bourbeuse and Dry Fork rivers. In 1961 McMillan (1963, 1965) conducted a large-area survey of the Gasconade River and its major tributaries. As a result, 160 sites were identified, and test excavations were made at several of them. These sites

included villages or campsites, caves/rock shelters, and cairns. It was noted that villages and camps were usually located at the base of bluffs, on second terraces or near the mouths of hollows and springs. Cairns were most often found on bluff tops over large streams, and major villages were often at the mouth of large tributaries.

In addition to these surveys, investigations at individual sites also were made. Descriptions of these can be found in site reports by Delling (1962a, 1962b), McMillan (1962), Price (1964a, 1964b), and Roberts (1965). Roberts, an amateur archaeologist from Waynesville, excavated at Tick Creek Cave, and his work resulted in the first major study of faunal remains from this region (Parmalee 1965).

By this time, more documentation of Archaic and Late Woodland sites had been gathered, but still little was known about Middle Woodland or Mississippian occupation of the area. Such a bias was to continue in the 1970s, when the implementation of federal legislation on historic preservation led to an increase in archaeological investigations.

In 1975 investigations began along a 20-km corridor in association with a highway project on Route 63. These included the first studies of the smaller tributaries and uplands of the central Gasconade drainage (McGrath 1977). Four of the open-air sites located in this survey were tested by Southwest Missouri State University between 1975 and 1977 (Cooley and Fuller 1977). In 1978 personnel from the University of Missouri at Columbia tested an additional eight sites (Reeder and Oman 1979). Smaller surveys also were conducted, such as those by Butler (1976), Cooley and Fuller (1975, 1976), and Turner and Helm (1979). Additionally, amateurs examined various caves and rock shelters (Jolly and Roberts 1974a, 1974b; Wessel 1974) and expanded some of the Route 63 excavations (Roberts 1978). These investigations also formed the basis of Reeder's (1988) dissertation in which he argued that inhabitants of the Gasconade River basin were not isolated geographically from other groups and that the culture history of the area fits the general midwestern cultural pattern.

Large-scale excavations also were conducted at two Late Woodland sites: the Feeler Site, 23MS12 (Reeder 1982, 1988), and the Kimberlin Site, 23CR301 (Geier 1975). The former project included the first paleoethnobotanical analysis for this section of the drainage (Voigt 1982) as well as the first soil-geomorphic study (Johnson 1982).

In the 1980s a series of major surveys was undertaken in the Mark Twain National Forest. Surveys were conducted outside the major valleys and, for the most part, identified small lithic scatters without diagnostic artifacts (Fraser et al. 1981; Klinger and Cande 1985; Perttula et al. 1982; Purrington 1985). The American Resources Group surveyed the 243-ha Kofahl Tract in 1981 (Fraser et al. 1981). Seventeen prehistoric sites, both open-air camps and lithic scatters, were identified. The sites are located on floodplain levees, terraces, alluvial fans, terminal ridge spurs, bluff crests, upland ridge crests, and hollow bottoms. Personnel from Southwest Missouri State University (Purrington 1985) surveyed an additional 1,215 ha and identified 15 limited activity areas, 12 "field camps," 6 cave/rock shelter sites, and 1 stone cairn. Most of these sites are located near large streams, but some are also present in the uplands. Purrington (1985) suggests that prehistoric site density was highest in the Rolla-Houston area of the forest and that this density is indicative of the real site distribution pattern and not a result of sample bias.

Perttula et al. (1982) also conducted investigations in a series of tracts and found two small prehistoric sites, 23PU194 and 23PU195. Purrington (1983) located two sites, 23PU198 and 23PU199, in another survey for the National Forest. Klinger and Cande (1985) surveyed 632 ha and located 10 small lithic scatters on ridge tops.

Previous Work in the Fort Leonard Wood Area

The 1970s also saw the first scientific investigations at Fort Leonard Wood. Garrison (1976) undertook a survey of a 16-ha tract for an air-to-ground weapons range, but no prehistoric sites were located. Purrington and Turner (1981) carried out survey of a 34-ha upland landfill tract. Two prehistoric lithic scatters, 23PU167 and 23PU168, were identified. Two surveys also were conducted by Major John Hargis (n.d.a, n.d.b) in 1980 and 1981. The first was located on Roubidoux Creek and the second in the Interior Uplands zone. He found 46 prehistoric sites, 13 of which are in the interior uplands. Due to changes in the boundaries of the military reservation, only 42 of these sites are currently located on the installation. The sites include cave/rock shelters, rock cairns and villages or campsites.

In 1981 and 1982, Environment Consultants, Inc. examined scattered tracts across the installation totaling 2,024 ha in extent (Niquette et al. 1983). Identified and partially evaluated were 53 prehistoric and historic sites. The prehistoric sites include 15 caves or rock shelters, 25 open sites, and 6 rock cairns. The historic sites are three late nineteenth/early twentieth century farms, a church from the same time period, and two military facilities (a bridge and generator). Twenty-five prehistoric sites and one historic site were thought to be eligible for listing in the NRHP. NRHP evaluation and nomination forms were completed for these sites but were not submitted to the State Historic Preservation Office (SHPO) for determination of eligibility. Another 68 prehistoric sites were identified but not evaluated, and no formal report on these sites was published. Based on review of ASM site forms for these sites, the Late Woodland period is best represented, but Middle and Late Archaic components are also commonly identified.

Niquette (1984) conducted a survey of an additional 1,035 ha in which 22 prehistoric and 11 historic sites were identified. Again, Late Woodland sites dominate in this sample, although Late Archaic sites are also well-represented. In the same year, Niquette (1985) also investigated 243 ha of timber sale tracts on steeply sloped terrain. These tracts were considered to be areas with low potential for containing archaeological sites and, not surprisingly, only three isolated finds were recovered.

In 1988 the American Resources Group studied 46 separate survey areas in Pulaski County, totaling 974 ha (Moffat et al. 1989). They identified 33 archaeological sites, eight of which had been previously recorded. Twenty-seven of the sites are prehistoric, and they are mainly open camps and lithic scatters. Also recorded were five rock shelters, a rock cairn, and a cave site. The six historic sites are late nineteenth/early twentieth century residences or farmsteads. Phase II evaluation was recommended for 25 sites. Also identified were 22 isolated finds.

In 1990 and 1991, American Resources Group conducted further Phase I investigations of selected timber sales and military training areas on Fort Leonard Wood (McNerney 1992; McNerney and Neal 1992). One prehistoric and eight historic sites were documented during survey of 17 timber sale parcels totaling 684 ha. Two military ordnance training sites and four historic farmsteads

were recommended for additional work (McNerney 1992). An additional 705 ha was surveyed in two timber sale parcels and three training areas located in the Interior Uplands and Big Piney resource zones, respectively. Eight prehistoric isolated finds, one historic isolated find, nine isolated historic features, one historic farmstead, and two prehistoric sites were located. One prehistoric site and the historic farmstead were recommended for additional Phase II investigation (McNerney and Neal 1992).

In 1992, Markman and Associates conducted Phase I inventory of two large contiguous tracts of 972 ha and 1,943 ha. The larger survey documented 25 historic sites, 20 prehistoric sites and 24 prehistoric isolated finds. Phase II test excavation evaluation was recommended for four prehistoric open sites, and avoidance and preservation was recommended for two cairns and four rock shelters. Phase II evaluation was recommended for four historic sites, and one cemetery was recommended for avoidance and preservation (Markman and Baumann 1993). In the smaller survey, 12 historic farmsteads or residences were documented and two sites were recommended for Phase II NRHP evaluation. No prehistoric sites were recorded (Baumann and Markman 1993).

Most recently, the University of Illinois conducted Phase I inventory of 783 ha in scattered tracts at Fort Leonard Wood. Forty-three new sites and 21 previously reported sites were documented (60 prehistoric, three historic, and one with both historic and prehistoric components). Phase II evaluation was recommended for 41 prehistoric sites (20 cave/rock shelters and 21 open sites), one historic site and the single site with mixed components. Four cairns are recommended for listing in the NRHP (Ahler and McDowell 1993).

Phase II investigations at Fort Leonard Wood have been few in number. The work conducted by Niquette et al. (1983) included test excavations at all reported sites. These excavations were usually limited to a single test unit, cleaning looter pit profiles and documenting the exposed stratigraphy, or occasional excavation of deep backhoe trenches. These activities were considered to constitute formal Phase II evaluation to assess NRHP eligibility criteria, and NRHP nomination forms were completed for the 14 sites included in the proposed Roubidoux Creek Archaeological District. However, these forms were never submitted for determination of eligibility.

Another Phase II investigation was conducted in 1992 by Markman (1993). His activities were limited to test excavations and partial damage assessment of Miller Cave (23PU2). Although the cave has been looted repeatedly, the excavations demonstrated that intact Early Archaic deposits were present in some portions of the site. NRHP nomination forms for Miller Cave were subsequently completed, and the Missouri SHPO determined the site was eligible for NRHP listing. The Miller Cave evaluation was the first Phase II evaluation done at Fort Leonard Wood since the 1982–1983 work conducted by Niquette et al. (1983).

Recently, the University of Illinois Public Service Archaeology Program completed Phase II NRHP evaluations at 15 selected sites on Fort Leonard Wood (Ahler et al. 1995). These sites were selected to provide a sample of prehistoric cave and open-air sites located in three of the cultural resource zones defined for the fort (see Edging 1992). All of these sites had been previously recommended for NRHP evaluation, and Niquette et al. (1983) had performed minimal evaluation work at two of the sites. Ahler et al. (1995) determined that 10 of the 15 sites contained scientifically significant information, and these sites were nominated for NRHP listing. The Missouri

SHPO concurred with these findings, and all 10 sites, including two in the Miller Cave Complex (Miller Petroglyphs and Sadie's Cave) were determined eligible for NRHP listing.

Previous Work in the Miller Cave Complex

The first work performed in the Miller Cave Complex was by Fowke (1922). His work focused mainly on conducting what would now be considered nonscientific excavations in the front portion of Miller Cave (23PU2). Over a period of about six weeks, a crew of locally hired excavators removed over 40 human burials, hundreds of projectile points, portions of ceramic vessels, and numerous complete bone, stone and shell tools from several excavation trenches placed in the well-lighted 30-x-25-m main chamber of the cave. In addition, another "seven wagon-loads" of unspecified broken stone and bone artifacts were removed. These collections are currently curated by the Smithsonian Institute, but have not received the benefit of reanalysis using modern typological classifications or other analytical techniques.

After Fowke's excavations, several local artifact collectors and relic hunters reexcavated portions of Fowke's trenches and expanded the excavation-damaged area to include most of the volume of sediments contained in the front, main chamber of the cave. These subsequent excavations have resulted in serious vandalism of the site and has lowered the integrity of the deposits considerably.

In spite of the damage sustained at the site, formal Phase II evaluation excavations conducted by Markman (1993) in 1992 documented intact Early Archaic deposits underlying excavation backdirt in at least one portion of the main chamber. In addition, Markman placed a test unit in the poorly illuminated southwestern lobe of the cave. This excavation unit documented essentially intact deposits that contained evidence of Late Woodland artifacts and features, including a dog burial. These findings led Markman to nominate Miller Cave for listing in the NRHP; the SHPO determined the site eligible for listing in 1993.

Though Miller Cave was determined to contain intact cultural stratigraphic deposits in at least two areas and the site was determined on this basis to be eligible for NRHP listing, Markman's work was considered to be incomplete. He did not document the extent of the intact cultural deposits within the cave as a whole, and a detailed site preservation plan was not developed. The present project was designed to address these two issues so that a more effective cultural resource management program could be effected for the most well-known site on Fort Leonard Wood.

Though Fowke's work in 1920 focused mainly on excavations within Miller Cave, he also documented artifacts on the bluff crest above Miller Cave (now the location of 23PU288), provided drawings of some of the Miller Petroglyph motifs, and noted the location of (but did not excavate) the nearby cairn site (23PU254). Though he described the environment around Miller Cave in some detail, he made no mention of Sadie's Cave. This oversight probably helped preserve Sadie's Cave from unwanted attention by relic hunters and vandals, leading to its nearly pristine condition when it was documented as a separate site by Niquette in 1982.

Niquette performed informal survey of portions of the Miller Cave Complex locale in 1981 and 1982. This work was done outside of his contractual survey areas, and consequently was not included in the final report (Niquette et al. 1983). However, ASM site forms were completed for

23PU235, 23PU254, 23PU255, and 23PU288, and his field and laboratory notes include information on these four sites. 23PU235 and 23PU255 were both described by Niquette, but no sketch map was made and he apparently conducted no test excavations. Niquette's field notes from his 1982 visit to Sadie's Cave clearly show that he recognized both the nearly pristine condition of the site and its research potential.

The next formal documentation of sites in the Miller Cave Complex derived from survey of timber sale tracts by American Resources Group in 1988 (Moffat et al. 1989). The survey crew documented the extent and condition of sites 23PU254 (Miller Cairn) and 23PU288, which had previously been reported by Niquette. They also documented another open site on the bluff crest above the Miller Cave bluff (23PU362) and another extensive bluff crest site (23PU361), located about 1.0 km northeast at the east end of the upland ridge that contains Miller Cave. Both of these sites were recommended for Phase II evaluation. The timber sale tracts did not include Miller Cave, Miller Petroglyphs or Sadie's Cave, so the American Resources Group field crew did not visit these sites in 1988.

In 1993, the University of Illinois Public Service Archaeology Program conducted Phase II NRHP evaluations at the Sadie's Cave and Miller Petroglyph sites as part of an larger testing program within Fort Leonard Wood (Ahler et al. 1995). These investigations provided the first detailed maps of these sites and documented their existing condition.

About 60 percent of the rock art had been either damaged or entirely removed from the Miller Petroglyph site because of vandalism activities over the last 30 or so years. Photographs were taken to document the condition of the engraved rocks, but no excavations were performed. Little soft sediment exists within the shelter containing the engraved rocks, and only one artifact (an unidentified projectile point base) was recovered from the site. In spite of the severe damage sustained at 23PU255, the site was recommended as being eligible for NRHP listing, and the appropriate nomination forms were completed. NRHP nomination was pursued because this site is apparently a unique cultural resource within Fort Leonard Wood, and because the remaining portions of the site, though damaged, still contain recognizable artistic motifs that provide information about the symbolism and world view of its inhabitants and which may be linked to specific temporal periods or cultural groups. The Missouri SHPO concurred with the assessment of the site's importance, and the site was determined eligible for NRHP listing in 1993.

Mapping within Sadie's Cave showed that unlike its nearest neighbors in the Miller Cave Complex, the site had sustained minimal disturbance by artifact collectors. Two large potholes and a series of small test holes spaced about 3 m apart were the only evidence of subsurface disturbance. The small test holes may have been excavated by Niquette's crew in its initial site documentation; they were partially filled with backdirt that had likely passed through 1/4" mesh screen. Excavation of two test units showed that cultural deposits and intact stratified Holocene sediments were confined to the eastern third of the cave and the vicinity of the cave mouth. The western portion of the cave showed evidence of episodic surface water runoff that essentially has prevented accumulation of Holocene sediment. Occasional Late Woodland sherds, and flakes, bone and shell were found scattered on the surface in the western two-thirds of the cave, but no midden or distinct artifact concentrations were observed. The test unit in the eastern portion of the cave revealed stratified cultural deposits at least 1.0 m deep. Excavation was halted before culturally sterile sediments were reached because a partially articulated human skeleton was encountered at 1.0 m below ground

surface in Test Unit 2. Based on recovery of several temporally diagnostic artifacts from these intact stratified deposits, documentation of the presence of surface and pit features, and recovery of bone, shell and carbonized botanical remains that could be used to reconstruct prehistoric diet and paleoenvironmental conditions, this site was recommended for NRHP nomination. The Missouri SHPO determined the site eligible for NRHP listing in 1993.

As part of a general attempt to educate the public about the cultural resources at Fort Leonard Wood, information/warning signs had been posted at several of the larger and more easily accessible cave sites on the fort, including Miller Cave and Miller Petroglyphs. These signs were posted after Niquette's visits in 1982 or 1983, and they informed visitors of the presence of an archaeological site and the fact that such sites are protected by Federal law from disturbances such as amateur excavation. Perhaps because the trail to Sadie's Cave is more obscure, no information sign was placed at this site. After revisiting the Miller Cave Complex sites in 1993 and observing the condition of other sites that had been posted with warning signs, the primary author noted that the presence of the information/warning sign seemed to attract attention and vandalism, rather than to deter such acts. As in Fowke's time, Sadie's Cave was spared serious damage largely because it was ignored, either intentionally or through oversight. Miller Cave and Miller Petroglyphs had sustained serious damage from vandals and artifact looters. Given the importance of the Sadie's Cave deposits and the fact that this site is also easily accessible to the public, Ahler et al. (1995) recommended that additional scientific excavations be conducted at Sadie's Cave before the site was irreparably damaged by vandals. The present project developed out of these initial recommendations.

Discussion of Previous Work

Most of the work performed at Fort Leonard Wood has been initiated to comply with the requirements of Section 106 of the National Historic Preservation Act. Moreover, the vast majority of compliance-related work at Fort Leonard Wood has been directed toward initial Phase I inventory of the existing cultural resources. Phase II evaluations at Fort Leonard Wood, though also considered to be a necessary part of the Section 106 procedures, have been much fewer in number.

Work performed by Niquette et al. (1983) and Niquette (1984) included limited test excavations and site evaluations in addition to the Phase I inventory, but most of the work is considered to be inconclusive in terms of formal NRHP evaluation and assessment. The most extensive testing work in these projects involved investigation of several rock cairns—open sites and rock shelters were only minimally explored. With the exception of the rock cairn investigations, none of the test excavations performed under these projects was grounded in local or regional research issues. Flotation samples were not collected for these projects, and subsistence and paleoenvironmental data are consequently severely restricted. These initial reports do provide good inventories and contextual information on some stratified sites, and the information, as far as it goes, appears to be accurate and reliable.

Markman's (1993) evaluation of Miller Cave was more research-oriented, and the project was conducted using modern recovery and analytical techniques. The botanical and faunal analyses presented in his report constitute the first systematic paleoenvironmental and subsistence data available for the installation, though the report is limited to examination of a single site.

The recent (and ongoing) Phase II evaluations conducted by the University of Illinois (Ahler et al. 1995; Kreisa 1995) were designed to sample systematically both open sites and cave/rock shelters located in various cultural resource zones within the installation and situated in a variety of physiographic settings. To date, 22 sites have been subjected to systematic mapping, geomorphic interpretation and limited excavation. Flotation and soil samples have been collected and analyzed systematically from appropriate contexts at all sites, providing a growing data base for investigation of prehistoric subsistence and paleoenvironmental conditions. This program of systematic Phase II NRHP evaluation is part of a multiyear program initiated and continuously supported by the Fort Leonard Wood Cultural Resource Manager. This program is designed to provide systematic NRHP evaluation of the fort's cultural resources and bring the installation into full compliance with the requirements of Section 106. In this way, the historic properties on the installation can be more effectively managed, balancing the needs of the Army with those of the scientific community.

In most cases, Section 106 compliance provides adequate recovery of scientifically significant information. However, there are circumstances where scientifically important sites (those determined to be NRHP-eligible) are potentially at risk of destruction or severe damage, and mitigation of the adverse impact (Phase III investigation through the auspices of Section 106) is not possible under the present conditions. It may be necessary to conduct more extensive investigations that allow development of a more complete scientific understanding of the site and its importance to regional research issues. It also may be necessary, based on those findings, to develop site preservation or stabilization plans that hopefully will allow an important site to be preserved in good condition for future research or as part of the regional cultural patrimony. In these circumstances, Section 110 of the National Historic Preservation Act provides for continued scientific excavation and recovery of scientific data from sites that have been determined to be eligible for listing in the NRHP, but are not being adversely impacted by Federal actions or projects.

Because of the continuing risk of vandalism to these three NRHP-eligible sites and the eventual risk of complete destruction of the contextual integrity of the deposits, it was believed that at minimum, a damage assessment should be conducted at all three sites and that site preservation plans should be prepared to address preservation of the scientific potential of each site for future needs. Preparation of site preservation plans required more detailed information about the integrity and scientific potential of the sites than was available from the Phase II NRHP evaluations. Collection of adequate information required a more detailed investigation of each site. In the case of the Miller Petroglyphs, this broader investigation required a more detailed documentation of the current site condition. In the case of Miller Cave, the enlarged investigations required documentation of internal site stratigraphy using minimally invasive techniques and interpretation of the location and condition of intact cultural stratigraphic deposits. In the case of Sadie's Cave, the more detailed investigations required excavation of several additional test units, documentation of internal site stratigraphy, collection and analysis of a larger samples of artifacts, and interpretation of the artifacts and ecofacts in terms of their potential contribution to regionally defined scientific research issues.

The expanded investigations of three Miller Cave Complex sites were conducted under the aegis of the Department of Defense Legacy Resource Management Program, which provided funding adequate conduct fieldwork, laboratory analyses, report preparation, and compilation of site preservation plans. The project was conducted under the provisions of Section 110 of the National Historic Preservation Act of 1966, as amended. This investigation of three sites in the Miller Cave Complex constitutes the first scientific investigation of sites on Fort Leonard Wood that were

conducted mainly for purposes of scientific research, and not purely for reasons of compliance with federal regulations. The Legacy Program provided the means to understand these important sites more adequately, and Section 110 procedures provided the opportunity to contribute substantive information to the body of scientific information in the region. It is hoped that other projects of this nature can be conducted at Fort Leonard Wood when circumstances promote the common goals of enhanced management of cultural resources and increased scientific understanding of these resources in a regional research context.

CHAPTER 4
GENERAL RESEARCH ORIENTATION

This chapter presents the general research orientation that guided investigations at the Miller Cave Complex. This chapter formally presents and summarizes the common research goals for the project that have been discussed briefly in relation to other topics in preceding chapters. Because each of the sites investigated here is very different from the others in terms of content, degree of preservation and nature of preserved materials, and scientific research potential, specific research goals for each site are developed and presented in later chapters, where both the context of the previous work conducted at each site and the condition and nature of each site can be discussed in detail.

The investigations were performed under procedures developed for implementation of Section 110 of the National Historic Preservation Act. This section allows for collection of scientific information from federally owned sites that are not adversely affected by direct federal actions. Such information should be collected through implementation of site-specific research designs and should be funded to permit adequate collection, analysis, interpretation and curation of materials and data pertinent to the research design. As stated above, site-specific aspects of the research design are discussed in later chapters, where the previous work at each site (which guided the research efforts) form a background context for the development of specific research goals.

There are four common research themes that connect all three sites investigated here. Because the sites are in close spatial proximity to one another and form what has been described as a site complex, it has been assumed that the sites are either temporally or functionally related to each other (or both). The first general research goal is to explore the validity of this assumption. In order to assess this assumption, additional information is needed from all sites.

The second research goal is designed to implement the first research goal through collection of additional samples of artifacts and ecological data from each site. These samples should be extracted from documented, controlled, intact stratigraphic contexts where possible, and will be analyzed to provide maximum information on temporal, functional and environmental aspects of each site. The data from each site then can be compared and contrasted, which will permit the nature of any temporal and/or functional relationships among these sites to be explored. Because each site is unique in terms of its information content, integrity and degree of preservation of specific artifact classes, individual sampling strategies will have to be developed for each site. These are presented in detail in subsequent chapters.

The third research goal common to all sites is to use the existing site documentation and the additional information collected at each site to evaluate formally the integrity and condition of each site. This will result in an assessment of damage incurred at each site as a result of both scientific investigations and unsystematic artifact collection. The damage assessment will be combined with contextual information collected during excavations and other investigations and with the analyses and interpretations of collections to address the fourth common research goal of the project.

The fourth goal is preparation of detailed site preservation plans that include an assessment of the information content of each site, the contextual integrity of the information, the amount and

nature of existing damage to the site, the potential of each site to produce additional scientific information important to regional research issues, and the potential temporal and functional relationships among the investigated sites. Actual implementation of the site preservation plans is not a goal of this project, but the preservation plans developed should be sufficiently detailed that implementation of them will require minimal additional site evaluation.

In the following three chapters, each site is discussed in detail. These discussions include presentation of background information on site setting and contexts, results of previous investigations, development of site-specific research goals, description of the results of investigations (including discussions of site stratigraphy, artifacts, temporal affiliation, environmental reconstructions, and site function, as appropriate), assessment of site-specific research goals, and evaluation of the scientific research potential of each site, based on the currently available information. In the last two chapters, the common research goals presented above are discussed and detailed site preservation plans are presented that take into account the content, contextual integrity, and scientific potential of each site.

PART II

SITE-SPECIFIC INVESTIGATIONS

CHAPTER 5
MILLER CAVE

This chapter presents the results of investigations performed at Miller Cave. A general site description is presented first, followed by discussion of previous work conducted at the site. Based on this context, site-specific research goals are developed and presented with appropriate methodology for attaining these goals. Results of investigations are then presented and interpreted. The final sections present evaluations of the site-specific research goals and evaluation of the future research potential of the site, based on the current understanding of the site context and integrity.

Site Description

Miller Cave is a large tube cave with a generally horizontal floor, located within the upper portion of the Gasconade formation outcrop overlooking the Big Piney River to the southeast. The cave consists of three main portions and there are several local landmarks within the cave that will be used as vernacular descriptions and points of orientation. These are shown on Figure 4. The following description emphasizes the present condition of the cave. Former conditions will be discussed in the context of previous work performed at the site (see next section).

The cave is most easily accessible by way of a narrow trail that winds down the upper bluff slope from the northwest and enters the smaller of the cave mouths from the west. This mouth is referred to as the cave entrance, as only the very sure-footed and light of body could enter the cave from any other direction or access route. The entrance is a dome-shaped opening about 3.5 m in height and 5.0 m wide. The trail follows through the entrance into a wide, straight passageway (Outer Passage) about 24 m in length that slopes down to the northeast, losing about 4.0 m in elevation in that distance. Along the southeast wall of the passage is a small opening in the bedrock (Window) which affords a spectacular view of the Big Piney River valley. The floor of the Outer Passage is covered with gravels and small cobbles near the entrance, and there are occasional large rock falls on the floor as well. The lower half of the passage has a soft sediment floor in some places, but this surface is convoluted with the remains of former excavations (potholes), and it is unlikely that any sediments remain intact in the Outer Passage. One large pothole was evident along the northwest wall of the passage floor; this fairly recent excavation was about 1.2 m deep and tunneled down to follow the edge of bedrock in this location.

The northeast end of the Outer Passage branches to the southeast and north. To the southeast is a broad opening (5.0 m wide and 4.0 m high; Secondary Cave Mouth) that provides another view of the valley and floor-level access to the steep bluff face. A sure-footed person could exit the Secondary Cave Mouth, skirt the bluff face to the northeast, and enter the Main Cave Mouth at its southwestern end. An alternate route to the southwest side of the Main Cave Mouth is through a low crawl space that branches northeast from the wall of the cave near the Secondary Cave Mouth. However, traverse of this passage requires a belly crawl (and at the time of our visit, also required an encounter with a large blacksnake that had made its home in the crawl space). The north branch at the end of the Outer Passage leads to a small opening in the rock wall (Doorway) that provides the easiest access to the Main Chamber of Miller Cave. The Doorway has a wide sill about 70 cm high, and the opening itself is roughly rectangular, measuring about 90 cm wide and 105 cm high;

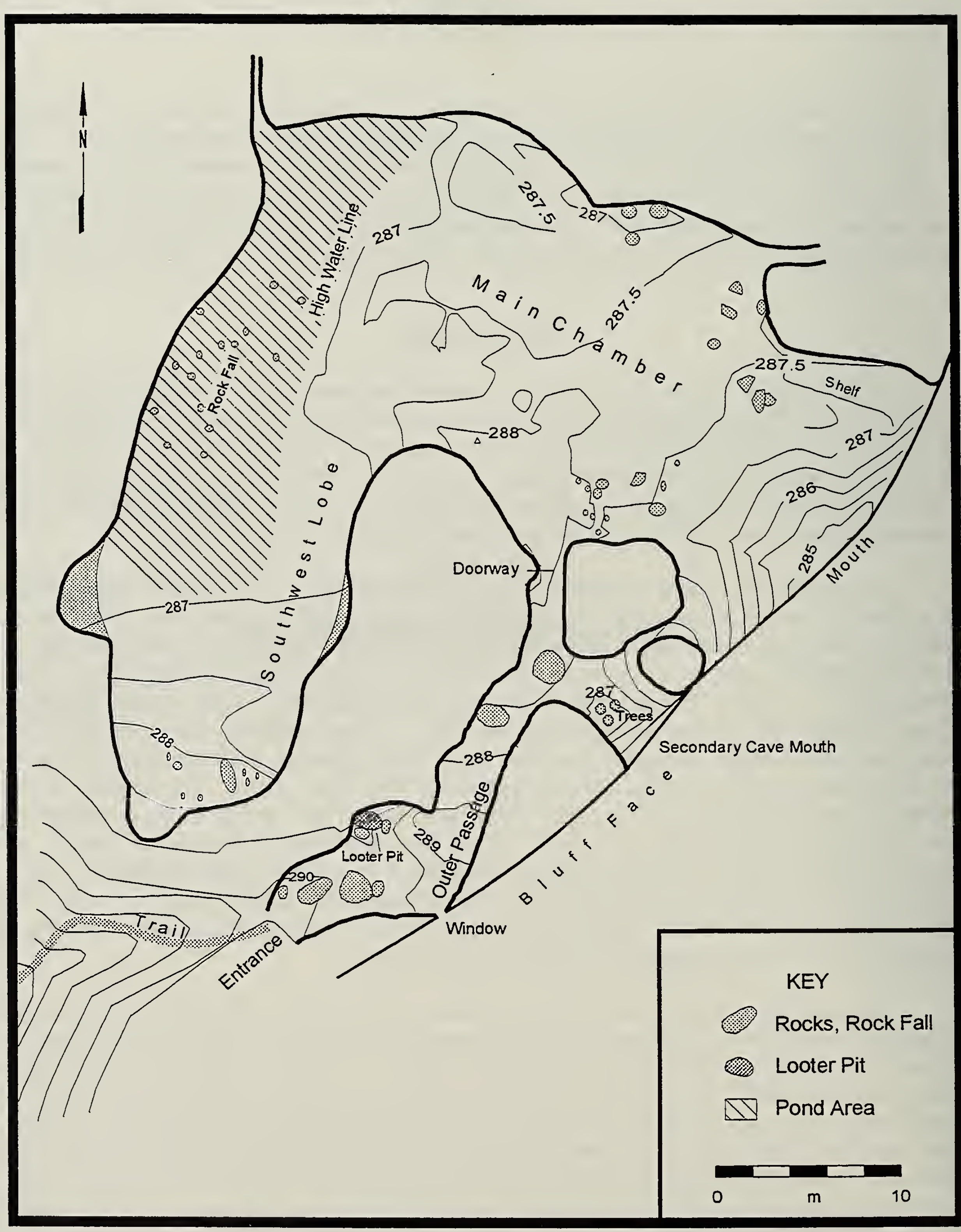


Figure 4. Plan of Miller Cave showing Contours and Major Internal Cave Features (adapted from Markman [1993], with additions based on observations from the present project).

the Doorway allows only individual access to the Main Chamber. The lower sill is worn smooth by the travel of numerous persons over the years.

The Main Chamber of Miller Cave is a large L-shaped area with generally straight northeast and northwest walls. The Main Cave Mouth is about 17 m wide and faces southeast. The floor is presently generally flat, but has many irregularities resulting from excavations and looting within the cave over the last 75 years. At the cave lip is a vertical bluff that drops about 9–12 m to the steeply sloping talus deposits. From the Cave Mouth, the floor slopes up sharply to the northwest for a distance of about 6 m, with semicircular contours forming a large bowl-shaped talus slope within the cave mouth. There, the floor attains its general elevation of 286–287 m. Several large trough-like depressions are visible in the cave floor, and these are interpreted as the remnants of previous excavation trenches, perhaps those of Fowke's 1920 work (see below). Numerous other smaller depressions on the cave floor mark isolated areas of looting or reexcavation of Fowke's backdirt. Occasional large rock falls are present on the floor, and most of these are near the northeast or southwest walls. A near-permanent pond is located along the northwest wall at the back of the cave. This pond dries out only about once every 10 or so years, according to local informants. At the time of our visit in September, the pond surface was very small, but the high water line was clearly visible and demarcated a generally rectangular area about 5–8 m wide (northwest-southeast) and 24–27 m long.

The Main Chamber makes a nearly 90-degree turn to the southwest about 24 m from the cave mouth, forming a large rectangular extension to the southwest of the main chamber (Southwest Lobe). The Southwest Lobe is defined as that portion of the cave that is poorly illuminated, southwest of the turn in the southern cave wall. The Southwest Lobe measures about 22 m (northeast-southwest) by a maximum of 12 m, narrowing to a rounded talus cone at the extreme southwest end of the cave. About 6 m southwest of the turn in the southern cave wall, the pond makes its closest approach to the southeast cave wall and the ground surface drops below 286 m elevation. Southwest of the pond, the ground surface rises again in a smooth slope to form a talus cone that eventually meets the cave roof at about 288 m in elevation. Though the ground surface in the Southwest Lobe also shows signs of disturbance and looter pit excavation, it does not appear to be as severely disturbed as the more well-lit portions of the Main Chamber.

Miller Cave is one of the largest caves on Fort Leonard Wood; the Main Chamber and Southwest Lobe of the cave have a combines surface area of about 1,015 m^2. The Southwest Lobe encompasses about 375 m^2, and the remaining 640 m^2 is in the Main Chamber. At least 750 m^2 of Miller Cave is illuminated well enough to perform most tasks without the aid of artificial lighting. However, as will be seen in the next section, virtually the entire surface of the cave contained evidence of human occupation, regardless of the lighting conditions.

Not included in the surface area calculations noted above are the areas enclosed in the Outer Passage and its two side branches. In addition, there are at least three side passages and smaller chambers that are part of Miller Cave, but which were not investigated in the present set of activities. At the north corner of the cave, a tall, narrow crevice formed from solution of a large block fracture of the bedrock continues northeast for at least 30 m, where it becomes too narrow to permit human passage. The floor of this passage is mostly mud and is largely inundated by the pond. In the northeast wall of the Main Chamber, a low, narrow side passage winds to the east and north, eventually branching into three other passages and small chambers. Fowke (1922) notes that

all of these passages contained cultural material, and all were apparently completely excavated during his field expedition in 1920. These passages and chambers were not explored or documented in the present investigations. Finally, a small cave is noted on the bluff side of the trail southwest of the Entrance (not shown in Figure 4). The entrance is about 1.0 m high and 0.8 m wide, with the ceiling falling rapidly to a low crawl space within about six meters of the entrance. Following the low passage into the bluff to the northwest, it opens into a low, dome-shaped chamber about eight meters in diameter. The ground surface slopes up toward the northeast, forming a talus cone that meets the ceiling. This talus cone may be the southern slope of the same talus cone that blocks the Southwest Lobe. If the two chambers were connected during the prehistoric past, this small cave would have provided another means of entry into the Southwest Lobe and Main Chamber of Miller Cave.

Previous Archaeological Work

The major elements of the Miller Cave ground plan have been constant throughout its historically recorded lifetime. The pond, as far as is known to local tradition, has always been located at the back of the cave. The various chambers and passages described above have been present in their recorded locations since the initial professional documentation of the cave in 1920. However, the sediments within the cave have undergone severe alteration as a result of both professional and nonprofessional excavations over at least the last 75 years. In order to better evaluate the scientific potential of the remaining Miller Cave deposits, it is necessary to have at least a general understanding of what the cultural deposits were like prior to major disruption. The following section provides a synopsis of the findings of the two professional excavation projects conducted at Miller Cave. These projects are those conducted by Fowke in 1920 for the Smithsonian Institution (Fowke 1922) and a damage assessment of the site performed by Markman and Associates in 1992 (Markman 1993). It does not attempt to describe any of the numerous nonprofessional excavations that were carried out during the intervening period of time. However, additional documentation of the site is available from a series of photographs taken in 1939 by Leonard Blake, a botanist and semiprofessional archaeologist from St. Louis. These photographs are reproduced in Markman (1993).

Smithsonian Institution Excavations (1920)

In 1920, Gerard Fowke conducted extensive excavations at Miller Cave (Fowke 1922) under the auspices of the National Museum of the Smithsonian Institution. These excavations were part of a larger investigation of cave and mound sites in the Ozark region of central Missouri and in surrounding regions. Of the almost 80 central Missouri cave sites reported by Fowke, the discussion of his work at Miller Cave comprises the largest portion of the report. The following discussion of excavations, findings, and site stratigraphy is extracted from Fowke's published report on the findings (1922:57–81). Major features of the internal cave configuration are shown in Figure 5. His report reflects the focus and state of understanding of archaeological inquiry at the time the work was conducted. As a consequence, there is a great deal of attention paid to description of burials and high-quality artifacts, and relatively little space devoted to discussion of contexts, stratigraphy or temporal periods represented. It is possible that the project notes that should be curated with the collections at the Smithsonian Institution contain more detailed descriptions of internal site stratigraphy and contextual data. Unfortunately, it was beyond the scope of this project to examine

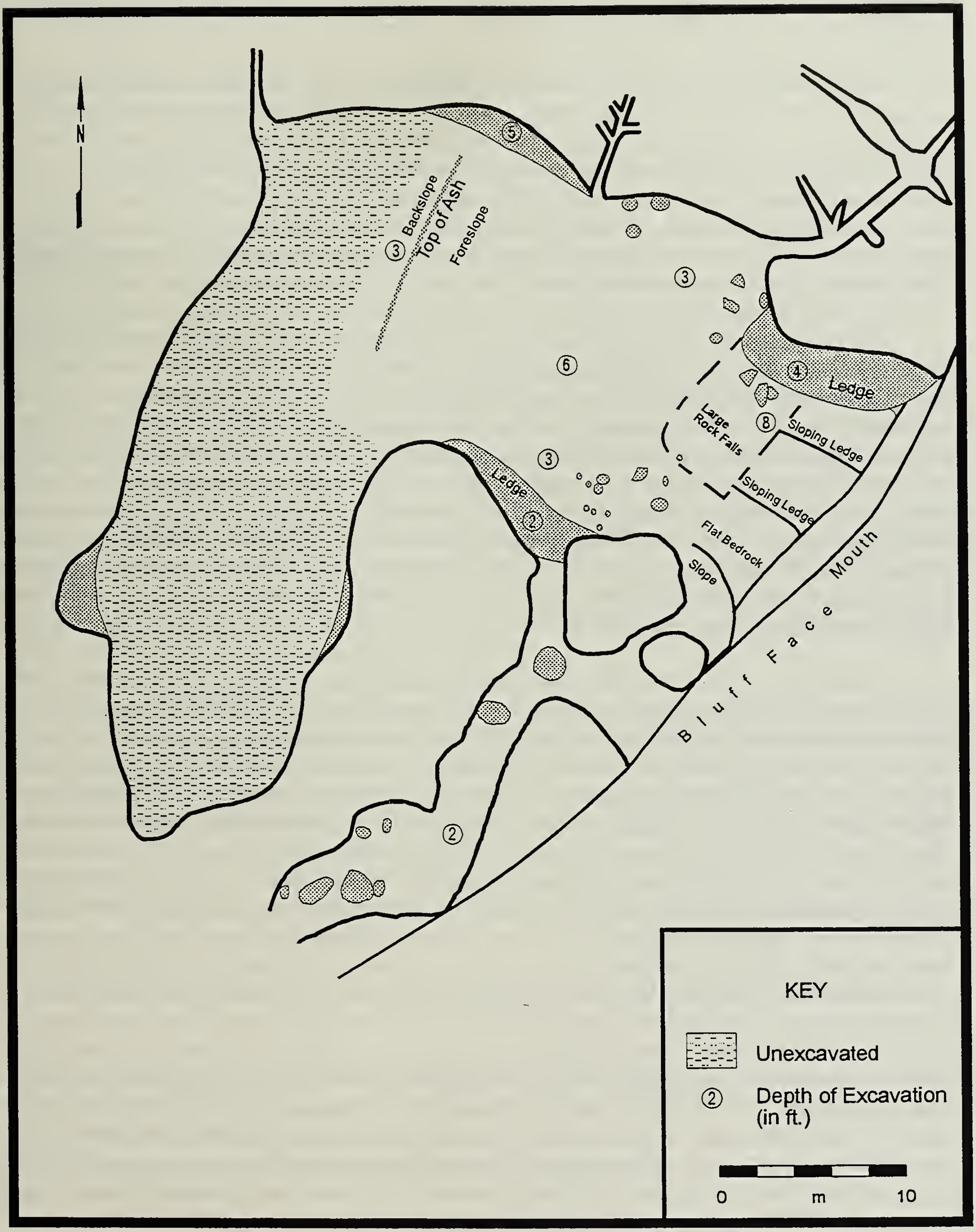


Figure 5. Reconstruction of Internal Features of Miller Cave from Fowke's (1922) Description of Excavations.

these records and the potential contribution of these documents to our current understanding of the site remains undetermined.

Fowke's account begins with a description of the landscape and region around Miller Cave, then delineates the location and condition of Miller Cave and other archaeological sites in the immediate vicinity. These other sites include brief mention of a large lithic scatter on the bluff crest above Miller Cave, a description of the nearby Miller Petroglyphs (now considered to be a separate site), and mention of three cairns on the bluff crest above Miller Cave (only one of which still exists). No mention is made of Sadie's Cave, though it is located only about 80 m southwest of Miller Cave at about the same elevation. Aside from documenting the motifs present in the Miller Petroglyphs, no work was conducted at the other sites; all investigations focused on Miller Cave.

Fowke mentions that the Outer Passage contained little in the way of archaeological deposits; a highly irregular bedrock surface was exposed at several places within 60 cm (two feet) of the existing ground surface. However, he notes that the talus slope outside the entrance and below the cave mouth contained large amounts of refuse that apparently had been discarded by the site inhabitants. Work began at the cave mouth, where a steep talus slope had been exposed. The initial goal was to excavate all sediments and expose bedrock over the entire cave floor. However, due to the presence of several large rock-fall blocks in the fill, efforts to reach bedrock were only partially successful. On the talus slope, the basal cave sediments had been partially exposed, and these consisted of "a mixture of sand, clay, and chert gravel." No depth of overlying deposits was noted, but recent observations of the cave mouth talus slope show ashy sediments about 1.5 to 2.0 m thick overlying crumbly basal red clay.

The upper surface of the clay was highly irregular, due partly to rock falls and partly to natural erosion of the clay surface. Fowke notes that the upper foot of the clay contained streaks of sand and ashes, and that mussel shell and a flint chip were recovered from this zone. Below this upper foot, the clay appeared to have been deposited by running water and there is no mention of artifacts incorporated into the sediment. The clay was variable in thickness. A sloping ledge that projected from the northeast wall was covered with only about a foot of clay; farther southwest and about 4.3 m (14 feet) into the cave, the clay reached its greatest thickness of 2.7 m (9 feet) above bedrock. The clay is noted as having layers of interfingered sand and clay. Intermixed with the clay was a considerable amount of chert gravel, which made excavation very difficult. Fowke correctly interpreted these sand and clay deposits as being of natural rather than cultural origin. At the point where the basal clay was thickest, it was intermixed with a large mass of rock-fall blocks that extended up to 6.7 m (22 feet) into the cave. The rock-fall mass was partially embedded in the basal clay deposits and also projected

above the clay; overlying ashy deposits were intermixed with the rock-fall blocks and removed during excavation. This rock-fall mass "interfered with excavation," and the rocks and underlying clay could not be removed without danger of catastrophic collapse. Consequently, there is a zone across the cave mouth and northwest of the talus slope where deposits were not removed all the way to bedrock; this zone of large rock-fall blocks may contain cultural deposits interspersed among the blocks and in the upper part of the basal clay deposit.

Recovery of cultural material from the upper portion of the basal clay is significant, as it indicates potential reworking of the basal clays and incorporation of artifacts due to sporadic

occupation prior to the time of major cultural occupation and midden accumulation in the cave. If the basal clay represents a Pleistocene-age deposit and the overlying ashy sediments are Holocene in age, reworking of the basal clay and incorporation of artifacts probably occurred during the Pleistocene-Holocene transition and most likely contains occupation episodes dating to the Paleoindian, Dalton and Early Archaic periods.

Fowke attempted to reach bedrock in two other locations, but large rock falls within the clay deposits prevented complete removal of sediment. After these efforts to reach bedrock failed, all work was concentrated on excavation of the upper ashy zone. This is particularly significant because of the likely presence of intact cultural deposit remnants within and underneath these large rock-fall blocks. A complete stratigraphic record is not present because of the removal of the overlying ashy deposits, but there may be large contiguous areas even in the Main Chamber that contain evidence of some of the earliest occupation episodes.

The side passages of the cave were thoroughly explored, and a sketch of their locations is provided on Figure 5. Almost all of these side passages contained artifacts and ashy sediment, indicating human use of all available surface area at one time or another during the Holocene. The back third of the northeast cave wall forms an overhang that measures about 9.0 m (30 feet) along the wall and up to 2.1 m (7 feet) to the northeast. Sediment completely filled the overhanging space so that it was hidden prior to excavation. In this area, the upper 60 cm of deposits consisted of ashy fill which was mixed with underlying loose dark sediments that contained decreasing amounts of refuse. Total depth of deposits was about 1.5 m (5 feet), with the lower boundary defined by saturated non-ashy sediments that could not be excavated. At the bottom of the ash deposits in this overhang was a cache of large, probably unfinished bifaces.

Fowke provides a relatively detailed description of the ashy deposits overlying the basal clay zone. When excavation began, there was a low crest of ashy deposits located about 25.5 m (84 feet) from the cave mouth. From this crest, the surface slopes down toward the pond at the back of the cave (backslope) and the sediments become much wetter. The slope toward the mouth of the cave is shallower than the backslope, and surface sediments were very dry. Depth of ashy deposits depended on the elevation of the irregular surface of the underlying clay and rock-fall zone. The ash was thickest (up to 1.8 m or six feet) between 15 and 23 m from the cave mouth, and depth decreased to about 0.9 m along the northeast and southwest cave walls. The average depth of the ashy zone was about 1.4 m (4.5 feet).

The ashy zone is noted as containing occasional "kitchen waste" and occasional discard of tools and flakes. Charcoal was nearly absent in the ashy zone, and much of the ash itself appeared to have been redeposited from remote points of origin within the cave. Fowke noted that there was some internal stratification within the ash; the layers were mainly level but sometimes followed the general slope of the underlying surface. The upper 10 cm of the ash was very loose and powdery; below this level the ash was laminated and more consolidated. The lowest portions of the ashy sediments also were very loose and unconsolidated. When the sediment occurred as consolidated masses of nearly pure ash, there were few artifacts included; in the darker ashy sediments, numerous artifacts were included in the deposits.

Also noted are numerous small, deep depressions that resembled postholes; these were often filled with sediment different from the surrounding matrix, and some intruded into the clay zone

below the ash. Fowke does not interpret these cylindrical pits as postholes because they are often completely enclosed even at the top margin; he also rules out animal burrows as the source of these disturbances. They probably represent a variety of cultural and natural disturbances, and little interpretation can be place on them without individual locations and descriptions. Shallow basins that served as cooking/heating facilities were also commonly distributed throughout the deposits. Occasionally larger basin-shaped pit features were found that had been excavated within or through the ashy deposits.

Fowke's account devotes considerable space to description of the burials, associated grave goods and other artifacts recovered at the site. Bone and shell are preserved in excellent condition. One burial in the upper portion of the ashy zone was noted as having coarse cloth adhering to the pelvic bones, suggesting the potential for preservation of uncarbonized organic remains in some portions of the cave. Interspersed with the descriptions of burials and features are occasional references to stratigraphic differences within the fill zone. One description of a posthole on the back slope of ashy sediments near the pond mentioned the presence of loose, dark deposits below the ash and overlying the red basal clay. Almost all of the burials described by Fowke were partial interments that had been disturbed by human or animal activity after burial. Fowke also notes the presence of many isolated human bones and fragments within the general ashy matrix. These observations suggest that the site witnessed relatively intensive occupation and activities throughout most of its history, resulting in disturbance of many of the burials by later site inhabitants.

Fowke's crew excavated all of the ashy deposits and loose earth for a distance of almost 28 m (91 feet) from the cave mouth, removing all sediments from the northeast cave wall to the southwest cave wall within the Main Chamber. He also excavated some sediment in the northeast end of the Southwest Lobe, but these were water-saturated and further work in the Southwest Lobe was abandoned. His excavations came within about 14 feet of the pond, and the sediments adjacent to the pond were also left unexcavated because of their waterlogged condition. In the back third of the Main Chamber, the basal red clay sediments began to slope down to the northeast and northwest, and the overlying sediments became dark and highly saturated with water. These sediments proved very difficult to excavate, and in general only the upper ashy sediments were removed, leaving the underlying wet, clayey sediments unexcavated.

The dark sediment was excavated to water level in one location on the rear slope about 5.5 m southeast of the pool. Dark, charcoal-rich sediment constituted the lower 0.6 m (3 feet) of sediment; at least the top few centimeters of the basal red clay also contained charcoal. Fowke interprets the charcoal in this deposit and the dark sediment itself to be of natural origin since no artifacts were recovered from within this stratum except for a few under the overhang and at the boundary with the overlying ashy sediments. He also notes that there were fewer artifacts on the back slope of the ash (on the slope down to the pond) than in the foreslope (facing the mouth of the cave), even though the ash on the backslope was clearly stratified.

Fowke attributes the basal red clay and sandy sediments to water flowing within the cave at various times in the past; he postulated an intermittent current through the cave system that was responsible for moving chert gravels, mud and sand into the cave from outside or transporting these sediments within the cave itself. He also interprets the dark sediments between the ash and basal clay to have had a similar origin; in this case organic-rich humus sediments from outside the cave were being redeposited on top of the basal clay. Habitation of the cave took place mainly after both

basal and dark sediments had been deposited, though there was some temporal overlap as shown by the interfingering of ashy and dark sediments under the overhang near the back of the cave.

A large variety of artifacts was recovered from the site, including ground-stone mortars, pestles, hammerstones, axes and celts; bone pins, awls and fleshing tools; mussel shell spoons and other artifacts; ceramics and pottery disks; and numerous unhafted and hafted bifaces in a variety of morphological styles. In spite of the obvious variety of artifacts, Fowke asserted that all forms are present in all portions of the deposits and that they therefore represent a single period of time or occupation. However, even a cursory examination of the projectile points illustrated by Fowke (1922:Plates 27 and 28) shows that occupation took place at least during the Early Archaic, Middle Archaic, Late Archaic to Late Woodland, and late Late Woodland periods.

In addition to the artifacts listed by Fowke as having been shipped to the National Museum (about 1,260 individual artifacts plus several lots of burials, pottery and miscellaneous items), he states that he left behind in the cave several hundred broken chert artifacts, over 250 ground-stone items, and the proverbial "several large wagon loads of shell, bone, and broken pottery." Most of these artifacts were not illustrated in the report, and to my knowledge, no professional analysis of the collections has ever been performed. Even though it is a biased sample of artifacts from the site, our understanding of regional culture history may benefit greatly from a more formal analysis of this collection.

This account of the 1920 excavations provides much important information about the internal structure of the cave deposits and the locations where potentially intact cultural and natural deposits may still be present. First, Fowke did not perform any major excavations in the Southwest Lobe, so this portion of the cave is most likely to contain intact deposits. Second, the backslope area (within about 5 m of the pond on its southeast side) and the overhang near the north corner of the cave both probably contain intact, but saturated, deposits below the depth of Fowke's excavations. Third, areas in the Main Chamber that contain large rock-fall blocks may also retain some intact deposits among and below the blocks. These are the only locations where intact remnants of the original ashy sediments are likely to exist. Finally, the upper portion of the basal red clay contained artifacts that are probably early Holocene in age. If these deposits were not completely removed, a thin veneer of sediment containing Paleoindian, Dalton or Early Archaic occupation episodes may be present over much of the Main Chamber area.

Leonard Blake Photodocumentation (1939)

Fowke also notes that Miller Cave was already disturbed at the time of his investigations. After his excavations were completed, the site was apparently visited several times by relic hunters who excavated additional areas or reexcavated Fowke's backdirt and removed many of the artifacts that had been left behind. None of these excavations have been documented, but there is evidence for continued disturbance of the site through a series of photographs taken in 1939 by Leonard Blake.

Some of these photographs are reproduced in Markman's (1993) report of the damage assessment of Miller Cave, and they will not be reproduced again here. The 1939 photographs of the Main Chamber show a gently undulating floor, cut by two long trenches that appear to have been relatively recently excavated. The same views of the Main Chamber in 1992 and our own

observations in 1994 show a highly convoluted surface with numerous small and large potholes and at least one large trench has a different orientation from the ones shown in the 1939 photographs. This surface attests to relatively intensive reworking of the Main Chamber deposits, though most of the holes do not appear to represent fresh site damage.

The extent of damage inflicted on any intact deposits remaining after Fowke's excavation is unknown and cannot be readily determined. It is possible that most of the potholes documented in the 1939 and 1992 photographs were placed in Fowke's backdirt and resulted in little new damage to the site. However, the documentation of the site by Markman clearly notes several recent potholes that attest to ongoing vandalism of this potentially valuable resource.

Damage Assessment and NRHP Evaluation (1992)

The most recent work at the site was by Markman and Associates, who performed formal damage assessment and NRHP site evaluation at Miller Cave in 1992. The resulting report (Markman 1993) demonstrated that the site contained undisturbed deposits in at least two locations. As a result of these findings, the site was recommended eligible for NRHP listing. The Missouri State Historic Preservation Officer concurred with this recommendation and the site was determined eligible in 1993.

Substantive contributions from this project include construction of a more precise internal map of the site, excavation of test units and trenches to expose undisturbed cultural deposits, recovery and identification of a sample of artifacts from both disturbed and undisturbed contexts, documentation of site stratigraphy in three locations, and determination of the only radiocarbon assay from the site. Using Fowke's description of the 1920 excavations as a guide, Markman located the probable positions of all burials described by Fowke in the 1922 report and noted the increased likelihood of encountering intact cultural deposits on the backslope and in the Southwest Lobe. It was observed that the general sketch map provided by Fowke was not very accurate, and that the orientation of the map was displaced about 45° from magnetic north. To correct this deficiency, Markman constructed a transit map of the Outer Passage, Main Chamber and Southwest Lobe portions of the site, but the small side passages were left unmapped. Contours were constructed using an arbitrary datum elevation of 100.00 m, and the resulting map (Figure 6) clearly shows the convoluted surface of the Main Chamber, the talus slope at the cave mouth, and the relatively undisturbed talus cone in the Southwest Lobe. The cave walls apparently were mapped by taping from various grid points. The cave wall location and shape shown in Markman's map is apparently the most accurate map available. This plan of the cave is incorporated into all of the maps presented here, with minor modifications based on later observations.

Based on Fowke's description of his excavations and the limited observations of internal site stratigraphy, Markman concluded that the most likely places for locating intact cultural deposits were in the back third of the Main Chamber and in the Southwest Lobe. Two test units and one trench were excavated accordingly.

Test Unit 1 was placed near the extreme southwest limit of the Southwest Lobe (Figure 6). A 1-x-2-m test unit was started, and when articulated dog skeletons were encountered, the unit was expanded to permit complete documentation of these remains. Markman documented a single intact cultural stratum in this location, consisting of an undifferentiated sandy loam with gravels; clay

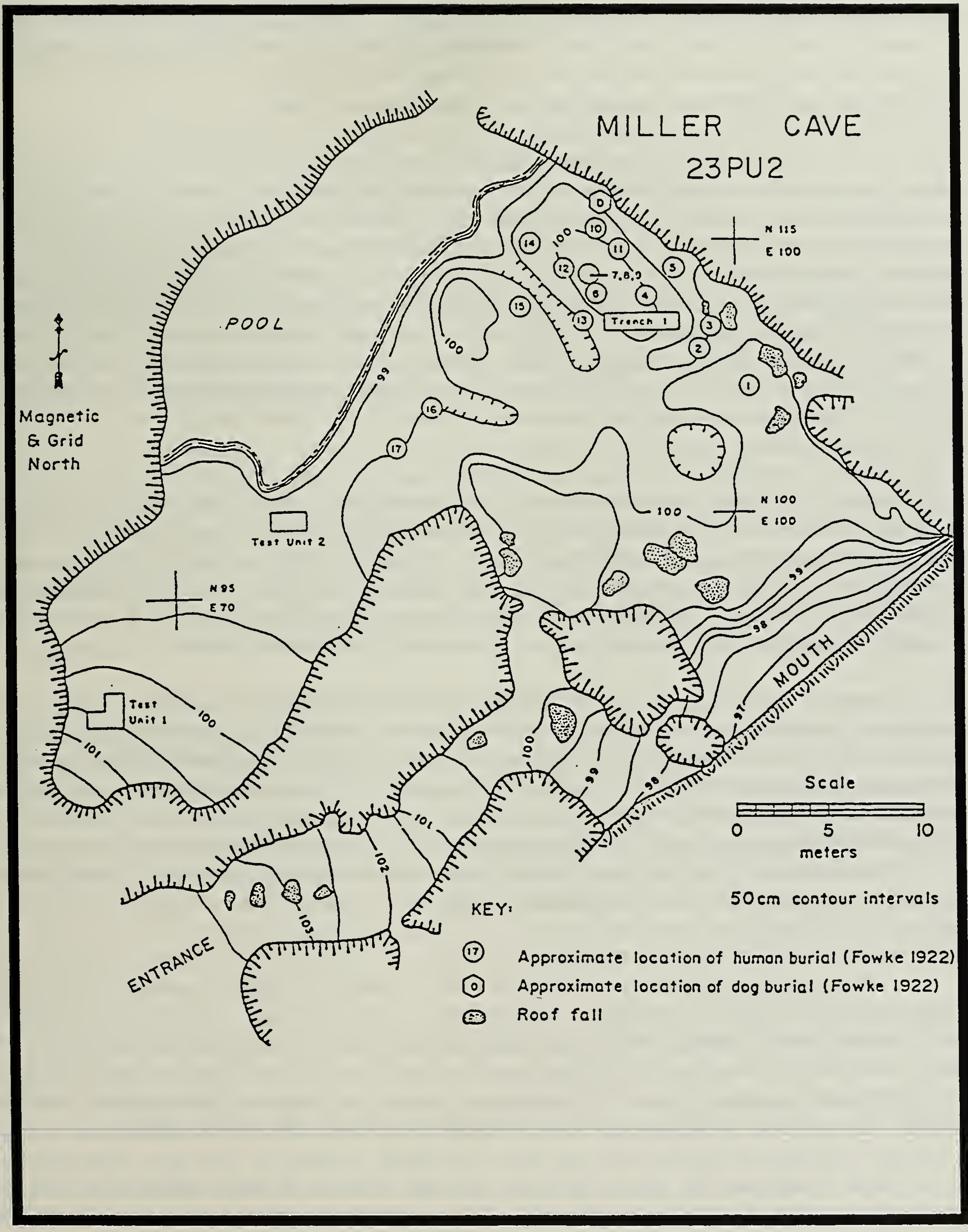


Figure 6. Location of Markman's 1992 Test Excavations at Miller Cave (from Markman 1993: Figure 1-5).

content increased with depth. Cultural material in the form of bone, shell, ceramic, and lithic artifacts were common in the upper levels, and density of cultural material decreased with depth. The lowest 10 cm of the excavations were designated as Zone 2 and were interpreted as a culturally sterile deposit; only two lithic artifacts were recovered from this zone. At 90 cm below surface a pavement of large cobbles was encountered and excavation was halted.

Late Woodland sherds and a Woodland (?) contracting stem point were recovered from the test unit near the dog burials. Probable Late Archaic and Middle Archaic points recovered from the test unit suggest the possible presence of much earlier deposits in this area. Analysis of a single flotation sample revealed high wood charcoal density and noted oak, hickory and unidentified wood charcoal, carbonized bark and grass stems, oak and hickory nutshell, and hackberry seed coats. Faunal analysis was reported for levels 5–9 of Test Unit 1. Mammalian faunal remains include the two nearly complete dog skeletons, white-tailed deer, mice, squirrel, pocket gopher, cottontail rabbit, and over 400 unidentified fragments. Bird remains include teal, hawk, owl, bobwhite, and unidentified bird elements; channel catfish and soft-shell turtle are also represented. Excavation of Test Unit 1 clearly demonstrated the presence of at least 90 cm of intact deposits in this portion of the Southwest Lobe.

Test Unit 2 was placed in a low area near the southern edge of the pool (Figure 6) in a location whose elevation was below the high-water mark of the pool. Sediments consisted of very sticky clay that was almost impossible to screen. A thin stratum (5–10 cm thick) of this clay overlay a pavement of cobbles that effectively halted excavation. No cultural material is noted as being derived from Test Unit 2, and no flotation samples were taken. Test Unit 2 was interpreted as containing culturally sterile fill that could not be assigned to a temporal period.

Trench 1 was a 4-x-1-m trench, oriented east-west, and placed to provide a cross section through one of the larger backdirt piles in the north quadrant of the Main Chamber (Figure 6). The trench was excavated in two sections—the eastern 1-x-2-m unit was designated Section 1 and the western 1-x-2-m unit was designated Section 2. Disturbed backdirt was removed from both sections in a series of arbitrary levels to expose the underlying undisturbed sediment surface between 100 and 120 cm below maximum ground surface (local datum). This surface represents the lowest extent of Fowke's excavations in this location. Section 1 was excavated only to the top of the undisturbed surface, and Section 2 was excavated another 60–80 cm to obtain a sample of undisturbed cultural and natural sediments.

The disturbed sediment was designated Zone 1, and it consisted of a sandy loam midden containing abundant cultural material. Modified and unmodified bone, modified and unmodified shell, pottery, lithic debitage, and chipped- and ground-stone tools were recovered. Temporally diagnostic artifacts from Zone 1 include Late Woodland and Middle Woodland pottery and 49 projectile points representing Late Woodland, Late Archaic, Woodland, Middle Archaic, and Early Archaic time periods. Bone includes a wide variety of terrestrial and aquatic species.

Zone 2 was observed only in the lower portions of Section 2, and consisted of a "dark clay speckled with charcoal" (Markman 1993:102). This zone probably corresponds to the dark earth that Fowke described as underlying the ashy deposits on the backslope of the cave. This zone contained abundant charcoal, and a 10-g sample of wood charcoal from the stratum yielded a radiocarbon assay of 8500±180 B.P. This assay confirms an Early Archaic temporal affiliation for this undisturbed

stratum. Corroborating the radiocarbon assay, eight temporally diagnostic Early Archaic projectile points were also recovered from Zone 2. These include examples of Rice Lanceolate, Rice Lobed, Hidden Valley and unidentified corner-notched types.

A single flotation sample (7 liters) produced wood charcoal (oak, hickory and unidentified species), bark, a single grape seed, a single nonspecific legume seed, and nutshell from black walnut, hickory, oak, and walnut family taxa. Faunal remains recovered from the same flotation sample include elements from bat, squirrel, gopher/rabbit, mice, vole, unidentified small-medium mammal, perching bird, unidentified bird, unidentified snake, frog/toad, gar, red horse, sunfish, unidentified fish, and unidentified gastropod taxa. The faunal remains recovered from screened samples from Zone 2 include 135 white-tailed deer elements and elements from pocket gopher, squirrel, raccoon, unidentified mammal of various size classes, turkey, unidentified bird, soft-shelled turtle, gar, small-mouth buffalo, red horse, indeterminate fish, and unidentified snail and mussel taxa. The variety of faunal taxa represented suggest that the Early Archaic occupations of the cave deposited a generalized mixture of subsistence remains.

The lower boundary of Zone 2 slopes down to the east in Trench 1, and it forms an abrupt contact with the underlying Zone 3 deposits. This zone consists of a "reddish or yellowish clay" containing few artifacts and several large pieces of rock fall (Markman 1993:104). It varies between 10 and more than 40 cm in depth, with the lower boundary either defined by large rock-fall blocks or remaining undefined. In general the yellow clay overlay the red clay portion of this zone. Markman notes that a few lithic artifacts and bone and shell fragments were recovered from the upper 25–30 cm of the zone; the lower 20 to 30 cm were culturally sterile. He interprets Zone 3 as a culturally sterile stratum; the low numbers of artifacts included in the zone migrated from above.

An alternative explanation for the presence of low numbers of artifacts in the upper portion of Zone 3 may be proposed. The artifacts in this zone could represent the remains of sporadic use of the cave during Paleoindian, Dalton or early Early Archaic times. The occupations may have been of short duration or intensity, resulting in minimal addition of ash, charcoal or anthrogenic sediment onto the basal clay surface. The upper portion of the basal clay would therefore have been minimally altered from its original state and only the presence of artifacts and bone in low frequency denote episodic use of the cave. Rates of natural sedimentation during this time span also would have been low, since this period predates the higher sedimentation rates that are often associated with the onset of the Hypsithermal climatic interval at around 8,500 years ago. In short, the upper, yellow-clay portion of Zone 3 may be alternatively interpreted as an intact cultural stratum, albeit one that contains little cultural material.

Markman's investigations clearly demonstrated that Miller Cave still contains intact cultural strata and also provided a much-needed temporal context for at least some of these deposits. Both the Southwest Lobe and the back portion of the Main Chamber contain intact cultural deposits, the location and condition of which were predictable based on knowledge of the extent of Fowke's previous work at the site. In addition, Markman's work provided official recognition of the site as one that meets NRHP eligibility criteria. However, the 1992 testing did not address the horizontal or vertical extent of the intact deposits; it merely demonstrated the existence of cultural strata in two potentially isolated locations within the cave. The report also did not provide a comprehensive damage assessment of the site and did not develop a plan to stabilize or preserve the remaining cultural deposits. The present investigation was designed specifically to address these questions.

Research Goals

Given the extensive damage that has been done to the site through previous excavations, the main research goals for Miller Cave were delineated as follows:

1) Construct a map of the cave system, including contours based on mean sea level elevations, that shows the location of intact deposits;

2) Determine the horizontal location, extent, depth below surface, and thickness of any intact cultural deposits that still exist within the Main Chamber and Southwest Lobe portions of the site;

3) Provide adequate descriptions of the major cultural and natural stratigraphic units existing within the Main Chamber and Southwest Lobe portions of the cave; and

4) Develop preservation and/or stabilization plans for the site that are consistent with the need to balance public access to the site against the potential for continued damage.

These goals were developed in consultation with the Fort Leonard Wood Cultural Resource Manager and were designed to be compatible with the long-term cultural resource management goals of the fort. The site had been determined eligible for listing in the NRHP, and it was the responsibility of the Fort to ensure proper stewardship and long-term preservation of scientifically significant sites. However, it was also known that Miller Cave has long been a scenic location that attracts several hundred civilian and military visitors each year; these visitors for the most part hike or picnic in the vicinity of the cave. Unfortunately, some of the visitors also excavate portions of the site, in spite of the posted information/warning sign placed in the cave mouth. An adequate preservation plan would need to incorporate efforts to secure the site against vandalism, which was viewed as the single most serious threat to the integrity of the site.

It was most desirable to develop a site preservation plan that would effectively protect the remaining intact portions of the site and at the same time permit continued public access. In order to develop a preservation plan that would provide a balance between site preservation and public access, it was necessary to determine as much as possible about the location, extent, integrity, and nature of any intact deposits remaining within the cave. To be consistent and protect the site as much as possible from unwarranted excavation, these investigations were designed to be largely noninvasive. Maximum information regarding site stratigraphy and extent of deposits could be extracted while inflicting a minimum amount of additional damage to this important site. A specific set of field methods was developed to meet these conditions.

Research Methods

At the outset, the best approach to reaching the above goals was a remote-sensing conductivity or resistivity survey. Under the proper conditions, such an investigation should be able to locate the upper boundary of intact deposits and provide a contour map of the boundary elevation, with 10-cm accuracy. At the same time, use of remote sensing technology would inflict almost no

damage to the existing deposits. To this end, the primary author contacted several archaeologists and geophysicists who had prior experience in remote-sensing on archaeological sites to discuss the feasibility of specific techniques. The general consensus was that the accuracy of results of conductivity and resistivity surveys would be low, and that we still would have to validate the results of the remote sensing data using "ground-truth" testing involving direct observation of internal site strata in cores or test units. It was also the consensus of these experts that ground-penetrating radar would provide a contour and thickness map of the desired degree of accuracy. Unfortunately, the cost of a ground-penetrating radar survey of Miller Cave was prohibitive.

Under these conditions, it was most feasible and cost effective to investigate the site through a series of small-diameter cores (2–5 cm) placed on a 2-m grid within the cave. The ground surface elevation at each coring point would be recorded and included on a detailed site map prepared prior to coring. All core profiles were to be recorded and logged. The depth to the top of undisturbed deposits, depth of undisturbed cultural deposits, and depth of noncultural deposits (if any) would be recorded for each core location. Any internal stratigraphy within the undisturbed portion of the core also would be recorded. Each major stratum observed within the site would be described using standard soil descriptive terminology (Agricultural Soil Conservation Service [ASCS] 1975), and each stratum would be classified as representing either disturbed, intact cultural, or intact noncultural deposits. Appropriate samples would be extracted from undisturbed cultural deposits for potential radiocarbon assay. Formally excavated test units would be kept to an absolute minimum, and would only be excavated if a completely undisturbed area was located. Based on the location, depth, thickness, and extent of undisturbed deposits, appropriate preservation plans would be prepared.

Results of Investigations

Surface Mapping

A map of the Outer Passage, Main Chamber and Southwest Lobe of Miller Cave was prepared using a Sokkia electronic theodolite and associated software mapping program. Mean sea level elevation was calculated from a spot elevation on the bluff crest southwest of the site, and an open elevation traverse was run from the spot elevation into Miller Cave. This traverse was also used to establish mean sea level elevations for the Miller Petroglyphs and Sadie's Cave. Once the traverse passed through the Outer Passage and the Doorway, Station 12 was established near the center of the southwest wall of the Main Chamber as the datum for an internal 2-m grid that extended to cover nearly the entire surface area of the Main Chamber and Southwest Lobe.

Bedrock ledges, turns, niches, and other features of the cave walls were mapped as were the locations of large, rock-fall blocks and rock exposed at the surface. The cave wall outline derived from this mapping compared very favorably with the map produced by Markman. The cave plan shown in Figures 4–9 is a composite compiled from our transit data and Markman's transit and taped measurements. Neither of these investigations mapped the small side passages noted by Fowke and added in sketch form to Figure 5.

After mapping internal cave features and general topography, the internal 2-m grid was established. This grid was oriented with grid East-West running parallel to the northeast cave walls to provide for more efficient placement of cores; orientation of grid north is on a bearing of about

Figure 7. Plan and Contour Map of Miller Cave Showing 1994 2-m Grid Points and Internal Contours Based on Mean Sea Level Elevations.

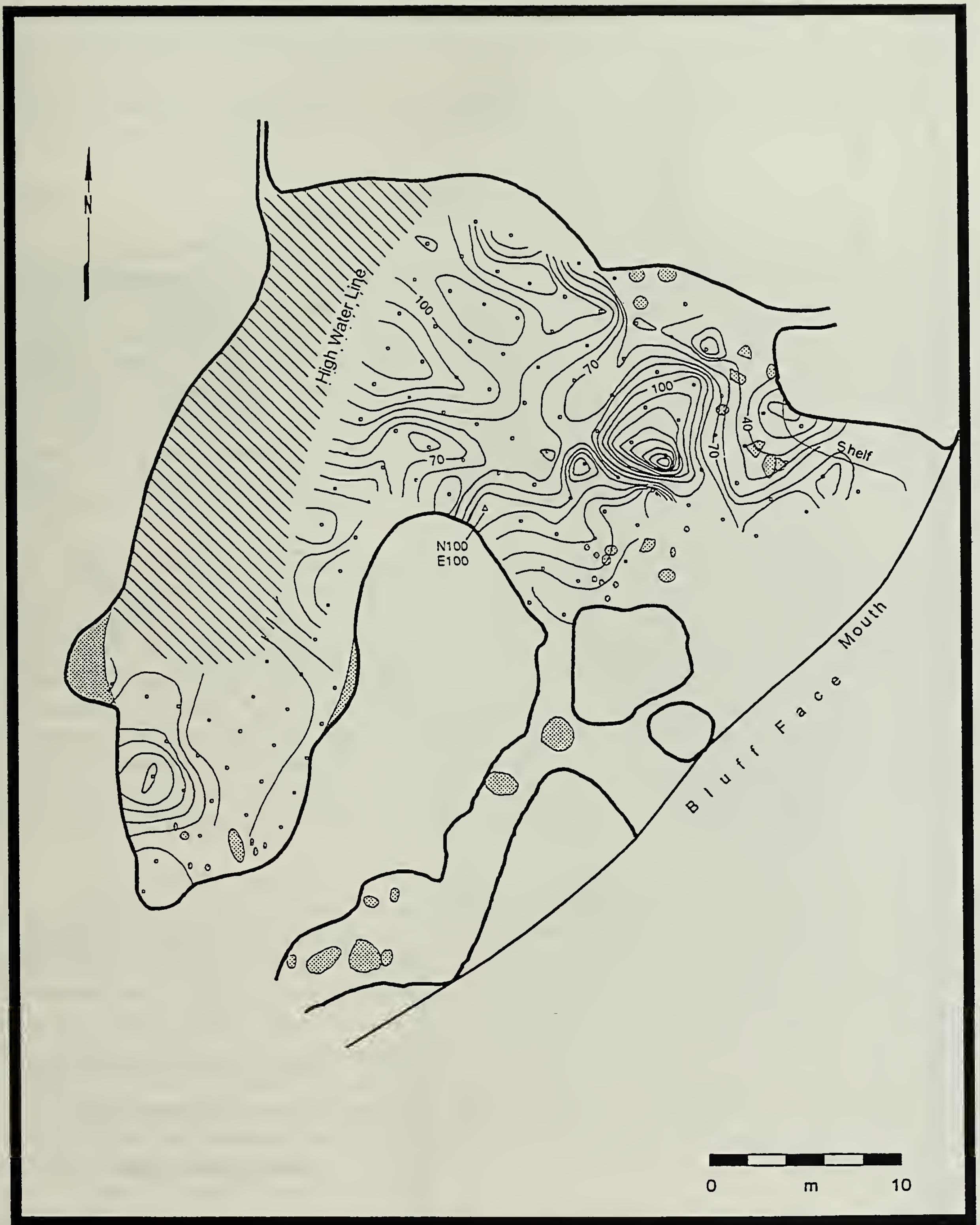


Figure 8. Distribution and Thickness of Disturbed Deposits in Miller Cave.

Figure 9. Distribution and Thickness of Intact Cultural Deposits in Miller Cave. Thickness is noted at each core location.

N42°E. The Station 12 datum (see Figure 7) was designated arbitrary N100/E100 on the internal grid. After setting in baselines running grid north and grid east-west from the datum, a tape was used to set the remainder of the grid points and extend the grid into the Southwest Lobe. Flags were placed at each even 2-m grid intersection. Topographic data were recorded at each flag. The grid points and associated topographic data were combined with cave margin data and used to produce the contour map shown in Figure 7.

Coring

A 2-cm diameter core was placed at each even 2-m grid intersection using a standard Oakfield coring device with appropriate extension rods. Elevation data had been previously recorded for each of these positions; depth of deposits and stratigraphic profiles observed in the cores were recorded on standard profile log forms. Depth of deposits, major strata and their boundaries, maximum depth of the core, and reasons for core refusal were all described and recorded for each core location. If rock was encountered near the surface which prevented a complete core profile to be extracted, the core was started again less than 20 cm from the marked grid intersection point. A maximum of three attempts to obtain a complete profile were made at each 2-m grid location; the deepest core derived from these attempts was documented. A total of 122 cores was documented in the Main Chamber and Southwest Lobe of the cave.

At the outset, it was anticipated that the upper stratum, especially in the Main Chamber, would consist of disturbed deposits that represented the backdirt from Fowke's and later excavations. This upper stratum was not expected to be culturally sterile. Fowke left behind a great quantity of artifacts and most small pieces of shell, bone, and lithic debris had not been extracted from the sediment during his investigations. Of greatest interest was being able to define the upper boundary of undisturbed cultural deposits in the limited exposures afforded by the small-bore cores. Through experience, we found that there were almost always textural and compaction differences that marked the upper boundary of the undisturbed deposits. Disturbed sediments were consistently very soft with an ashy silt loam or loam texture; underlying undisturbed cultural deposits most often were more clayey in texture, had lower ash content and were noticeably more compact.

Twelve major stratigraphic units were documented during the coring. These major strata were defined as being consistently represented in terms of texture, inclusions and general stratigraphic position in at least three core locations. Table 2 presents formal descriptions of the major strata. None of the strata exhibited any indications of pedogenesis, which was expected given the absence the contribution of vegetation to soil formation processes within the cave environment. Sediment structure was omitted from these descriptions because the small volume extracted from cores often prevented accurate determination of structure. However, all strata that are interpreted as disturbed deposits would be considered structureless. It is expected that all intact noncultural strata would generally have a subangular blocky to angular blocky structure, based on observation of similar basal sediments in the nearby Sadie's Cave and in other cave deposits in Fort Leonard Wood (see Ahler et al. 1995).

The major strata were initially grouped into three classes based on field observations of texture, inclusions and boundaries. Strata I, IC and exposures of IA north of the N91 line (IA-N) are interpreted as disturbed cultural strata. Strata IB, ID, IV, VI, VII, and exposures of IA south

Table 2. Descriptions of Major Strata Observed in Cores at Miller Cave.

Stratum	Color	Description	Lower Boundary	Thickness Range (cm)
Disturbed Strata				
I	10YR4/3	Loose, very friable ashy silt loam with moderate amount of cultural material and occasional charcoal	Abrupt to clear	3–203
IC	7.5YR4/4 to 4/5	Firm, moist silty clay with little ash or charcoal	Abrupt	0–7
IA-N	7.5YR4/4	Loose silty clay with moderate amounts of charcoal, ash, and shell. Occasionally mottled with sediment from strata II or III	Abrupt to clear	0–55
Intact Cultural Strata				
IA-S	7.5YR4/4	Firm silt loam to loam with moderate amount of charcoal, ash, and shell. Not mottled with sediment from strata II or III	Abrupt to clear	0–118
IB	5YR5/8	Firm ashy silt loam with large amount of charcoal and occasional shell and bone; may correspond to Fowke's layer of "dark earth" on the backslope of the ash	Abrupt to clear	0–44
ID	10YR4/4	Very firm silty clay with occasional charcoal and sediment mottles from lower strata	Abrupt to clear	0–25
IV	10YR6/6	Firm silty clay with low charcoal content; often occurs as a thin layer overlying noncultural sediments	Abrupt to clear	0–3
VI	10YR7/6	Firm ashy silt loam with occasional charcoal, bone or shell fragments. Very similar to Stratum IB, with less charcoal	Abrupt to clear	0–7
VII	10YR4/4	Firm silt loam with moderate ash, charcoal and cultural material. Most common in Southwest Lobe area	Abrupt to clear	0–45

Table 2. Concluded.

Stratum	Color	Description	Lower Boundary	Thickness Range (cm)
Noncultural Strata				
II	7.5YR5/6	Very firm silty clay with occasional small gravels; no cultural material or ash	Not observed	0–32+
III	5YR5/8	Very firm silty clay; no cultural material or ash	Not observed	2+
V	5YR5/8	Very firm sandy clay; no cultural material or ash	Not observed	3+

Table 3. Summary of Soil Chemistry Analyses for Miller Cave Strata.

Stratum	pH	%OM	Phosphorus (ppm)	Potassium (%)	Magnesium (%)	Calcium (%)
Disturbed Strata						
I	8.9	3.1	164	0.218	0.170	2.856
IA-N	8.9	3.2	162	0.259	0.215	8.008
IC	8.2	1.4	132	0.049	0.157	3.324
Intact Cultural Strata						
IB	7.9	3.3	147	0.040	0.138	1.854
ID	8.1	3.5	166	0.062	0.179	4.088
IV	8.5	3.4	144	0.230	0.252	4.088
VI	8.0	3.4	165	0.054	0.149	3.964
VII	8.6	2.8	127	0.016	0.260	4.944
Intact Natural Strata						
II	8.4	0.8	129	0.050	0.166	4.855
III	8.1	0.9	137	0.043	0.140	0.970
V	8.2	0.9	152	0.070	0.117	0.703

of the N91 grid line (IA-S) are interpreted as intact cultural deposits. Strata II, III and V are consistent with observations of intact, but noncultural strata in other sites in the area.

To identify other attributes that might be shared among strata within a given class, and to try to confirm the field determinations of these classes using independent attributes, selected chemical analyses were performed on samples from each major stratum. Samples massing approximately 20 g were sent to Ingram Soil Testing Service, Sullivan, Illinois, for determination of concentrations of a suite of standard chemical constituents. Tests run on the samples included determination of sediment pH, percent organic matter (OM), and concentration of total phosphorus (in the form of PO_4 phosphate), potassium, magnesium, and calcium. Table 3 shows the findings of these chemical analyses.

Some general observations can be made from the Table 3 data that tend to support the field interpretations presented above. First, all intact natural strata have low organic matter content compared to other strata. This was to be expected because of the likely source of these deposits as Pleistocene-age residuum; organic matter should be nearly completely leached from these sediments.

Second, strata I and IA-N exhibit high potassium levels, consistent with visible observations of high ash content. Stratum IC was ultimately interpreted as a disturbed stratum. The analysis of the Stratum IC sample shows a low level of potassium, even though as a disturbed stratum it might have been expected to exhibit high ash levels. Stratum IC is found only in the lower portion of a few profiles, and field observations indicate that it is low in visible ash and charcoal content. The chemical analyses thus appear to support the visual field descriptions and interpretations for this stratum.

An alternative interpretation of Stratum IC also can be offered. This stratum occurs in only a few places (four locations on E94 line), is thin, and has been found just above red clay (two instances), above rock (one location), and interbedded with disturbed Stratum IA deposits (one location). It may represent a generally intact cultural stratum, and the low potassium signature is consistent with the chemical signatures of other intact strata. If the relatively low organic matter content for Stratum IC is also considered, it is possible that this stratum is an Early Holocene deposit that represents a depositional and temporal transition between the basal noncultural residual clays and the overlying cultural midden deposits. This stratum may be similar to TU2/Stratum 5, TU5/Stratum 8, and TU3/Stratum 4 in Sadie's Cave.

Third, the Stratum IV sample is anomalous in its high potassium content relative to other intact cultural strata. The location given for the sample provenience (N110/E110, 40–45 cm bs) is not indicated as Stratum IV on the field core profile for that location. Instead, Stratum IA is shown, which is more consistent with the high potassium content. A review of the locations recorded for Stratum IV indicates that it is probably an intact cultural stratum, though this interpretation cannot be supported or denied using the chemical analyses. It is most often found near the east pond edge and in the southwest lobe of the cave, it often occurs just above bedrock, and it is often overlaid by other strata such as IB and IA-S that have been interpreted as intact cultural deposits.

The chemical analyses generally support the field interpretations and classification of major strata into disturbed, intact cultural and noncultural classes. The nature, variability and distribution of each of these strata classes is needed to determine the extent of potentially scientifically significant

deposits and develop appropriate site preservation plans. The strata classes are discussed below, with individual strata examined in detail as needed.

Disturbed and Noncultural Deposits. The disturbed deposits (strata I, IA-N, and IC) have a single attribute in common—they are all very loose and friable. During coring, these sediments often were compacted by the coring tool, at times compressing a meter of loose sediment into 25–30 cm of more compacted sediment in the core tool. In addition, strata I and IA-N also have high ash content and probably represent the backdirt for Fowke's excavation of the "ash deposit." Taken as a group, the disturbed strata are thickest and most continuous in the Main Chamber. Figure 8 is an isoline map showing thickness of disturbed deposits as observed in the cores; isoline interval is 10 cm. This map and Figure 9 were produced using the Surfer software mapping program, using three-dimensional data extracted from the core logs.

The Main Chamber cores should probably be considered to represent minimum thickness data, since about half the cores in this part of the site did not reach noncultural deposits. Instead, the core often refused on rock at relatively shallow depths; the core locations that refused on rock are marked with a solid dot on Figure 8. The distribution of these cores in the Main Chamber is consistent with Fowke's description of large rock falls in the front half of the cave. In the back half of the Main Chamber, closer to the pond, more of the cores exposed the underlying noncultural residuum of red clay, sandy clay and silty clay. However, rock falls are still common in this area as well. Cores in the Southwest Lobe generally did not reach noncultural soft sediments. This observation is consistent with Markman's (1993) description of the base of Test Units 1 and 2, which were described as a solid pavement of cobbles. This pavement may represent roof fall, and it is unknown if there are intact cultural strata underlying the rocks. When rock fall was encountered under disturbed deposits, it was impossible to determine if the rock represented the depth of previous excavations or if Fowke or others excavated much deeper in the area. Because of the presence of so many rock falls, a meaningful contour map of the top of the noncultural sediment surface could not be prepared.

Intact Cultural Deposits. Underlying the disturbed deposits in some locations were the strata interpreted as representing the remnants of intact cultural deposits. Figure 9 shows the distribution and thickness of intact deposits within the cave. This overall distribution is also very consistent with Fowke's description of his investigations. Toward the back of the Main Chamber, where sediments are very moist to wet, Fowke did not excavate the cultural deposits completely. The present data indicate that a thin veneer (generally less than 20 cm thick) of intact cultural sediment remains southeast of the pond in a band about 6 m wide. Strata in this band are primarily Stratum IB sediments with minor contributions from strata ID, VI and VII. At the northern limit of our coring is a single location (N114/E96) that showed at least 61 cm of intact Stratum IB deposits underlying 65 cm of disturbed sediment. This location is near or partially sheltered by the overhang described by Fowke in the north corner of the cave, and the presence of Stratum IB deposits is consistent with his description of "dark earth" underlying the ash in this area.

Immediately south of the turn in the cave that marks the boundary between the Main Chamber and Southwest Lobe, the intact cultural deposits become thicker. However, these intact sediments are still overlain by 20–40 cm of disturbed deposits. Fowke did not describe any excavations in the Southwest Lobe, and the disturbed deposits probably result from activities of later vandals who excavated several potholes along the southeast wall of the Southwest Lobe.

The cores on the E94 line from N90 to N94 show thick disturbed deposits and less than 2 cm of intact underlying sediment. However, farther south into the Southwest Lobe, disturbance appears to be more localized. Intact deposits range in thickness between 25 and 108 cm over most of this area, and some cores showed no disturbed sediments. Intact deposits are less than 20 cm thick only along the southeast and northwest walls, and disturbed deposits are generally thin (<30 cm) in these locations as well.

Only one other location containing substantial intact deposits was encountered. In the front portion of the cave, a core at N108/E110 showed 52 cm of intact deposits underlying 40 cm of disturbed sediment. This core was placed among several large rock-fall blocks and confirms our earlier supposition that some cultural deposits may remain intact among the larger rock-fall areas that Fowke did not excavate.

The distribution of intact and disturbed deposits discussed above indicates that Fowke's excavations contributed the most damage to the cave. Subsequent looters and vandals have disturbed some additional deposits, but their efforts are on a much smaller scale than Fowke's, and the resulting damage to the site has been less severe. It is possible that later artifact collectors spent much of their time sifting through Fowke's backdirt. Based on Markman's analysis of a 25 percent sample of the disturbed deposits from his Trench 1, the upper disturbed zone is apparently still rich in cultural material. However, in spite of the abundance of material in this upper zone, the scientific potential of the material is diminished because of the lack of stratigraphic integrity.

Artifact Assemblage

No artifacts were collected from the cores, and no formal excavations were conducted during our investigation of Miller Cave. In addition, the crew was instructed to leave all surface artifacts in place unless they were temporally diagnostic. However, we did recover one artifact from the surface. A large sandstone slab that had been used as a grinding stone/metate was found within the high-water mark of the pond near the back of the cave. This artifact was mapped and collected because of the high probability that looters would soon remove this object. After it was dried and cleaned, the artifact proved to have a shallow depression on one side and ground hematite pigment was embedded over most of the surface. This temporally nondiagnostic artifact constitutes the entire artifact assemblage from our investigations.

Evaluation of Research Goals

Earlier, four site-specific research goals were delineated for Miller Cave. The mapping and coring programs outlined above have resulted in accumulation of data sufficient to achieve these research goals. Evaluation of each research goal will be discussed below.

The first goal was to construct a map of the cave system, including contours based on mean sea level elevations, that could be used to show the location of intact deposits and relocate these areas during later investigations of the cave. This goal was accomplished, and the transit and grid data are curated with the documentation of the other activities. A stake was placed at the Station 12 N100/E100 datum, and this was driven almost flush to the ground. Two ½-inch diameter pipe segments with plastic caps were placed on the N100 base line and another was placed on the E100

grid line so that the grid placement and orientation could be reconstructed. These pipes were driven flush to the ground and covered with 1-2 cm of disturbed sediment. Grid locations and elevations of these pipes was documented and curated with the project notes.

The second goal was to determine the horizontal location, extent, depth below surface, and thickness of any intact cultural deposits that still exist within the Main Chamber and Southwest Lobe portions of the site, using techniques that were minimally invasive to the intact sediments. The data presented in Figures 8 and 9 and discussed above show clearly the horizontal location extent, depth and thickness of intact deposits as well as the overlying disturbed sediments. This goal has been reached.

The third goal was to provide descriptions of the major cultural and natural stratigraphic units encountered during the coring. These strata were described in Table 2 and chemical analysis of samples from most of these strata provided support for our classification of them as representing disturbed, intact cultural or intact noncultural deposits.

The fourth goal was to use the data compiled above to develop site preservation and/or stabilization plans. These plans would attempt to evaluate systematically the scientific potential of the intact deposits and balance the need for site preservation with the desire to keep the site accessible to the public.

After completion of the fieldwork, the core and map data were compiled to produce the maps and composite data presented above. With this information, the primary author met with personnel at the U.S. Army Corps of Engineers Waterways Experiment Station (WES) to develop more specific plans for site preservation and stabilization. Present at this meeting were Paul Albertson, a geologist attached to WES, and Dr. Chris Mathewson, a geological engineer with previous experience in implementation of site preservation and stabilization plans. After examining the composite data, we concurred on the following observations regarding the potential for encountering intact cultural sediments in various portions of Miller Cave.

First, based on the location and thickness of intact deposits, the southwest lobe of Miller Cave has the highest potential for containing intact deposits that are of significance to regional research issues. The intact deposits are consistently thicker and in some locations show no evidence of previous disturbance. Second, a 6-m wide zone on the southeast edge of the pond also has high potential, but the intact deposits here are buried by up to 40 to 80 cm of previously disturbed overburden. Third, a small isolated pocket of buried intact deposits is located in the front third of the cave near a large rock fall. This location is of limited extent and has been partly disturbed by Fowke's excavations. Fourth, the remainder of the deposits within the cave are disturbed and have little archaeological potential or significance to the region beyond providing artifact faunal, and botanical assemblages that have no contextual integrity.

Based on these observations, we attempted to classify portions of the site according to a system previously devised and used by Mathewson that addresses the scientific significance of the deposits and its NRHP status. In this system, Class V represents portions of the site that contain deposits in intact stratigraphic contexts that are demonstrably scientifically significant and would be eligible for NRHP listing. Class IV deposits are potentially scientifically significant and would probably be eligible for NRHP listing. Class III deposits are potentially scientifically significant, but

are not considered eligible because of poor context of other problems with integrity. Class II deposits are not considered scientifically significant, but may be NRHP-eligible for other reasons (unique site, representative of a time period, etc.). Class I deposits are sites or portions of sites that are neither scientifically significant nor NRHP-eligible based on other criteria. Class 0 represents nonsite portions of the landscape.

Using this classification scheme, the Southwest Lobe and the 6-m wide zone on the southeast side of the pond are considered to contain Class V deposits. The isolated area of intact deposits around the rock fall near the cave mouth is considered to be a Class IV deposit. The remainder of Miller Cave is classified as Class III because the entire site has been determined to be NRHP-eligible, but the integrity of the deposits has been destroyed. Figure 10 shows the distribution of the Class III, IV and V deposits.

After classifying the internal site deposits into various preservation classes, several approaches were discussed regarding specific site preservation and stabilization procedures. The specific recommendations for site stabilization were developed to fulfill simultaneous goals of 1) keeping the site generally accessible to the public; 2) preserving the integrity of deposits according to their preservation rank (with Class V highest), and; 3) providing cosmetic repair to the Main Chamber and Southwest Lobe areas. The following specific courses of action were recommended:

A) The front portion of Miller Cave should be smoothed, removing the potholes and evidence of surface disturbance. This can be accomplished by raking and redistributing the existing disturbed sediments without inflicting damage on underlying intact deposits.

B) The remainder of the Main Chamber floor also should be smoothed, and the disturbed surface deposits mixed with a hardening agent to produce a "gunnite" surface. This action would result in a hardened surface about 2 inches thick composed of on-site sediments. This hardened surface will effectively seal lower, intact Class V deposits and discourage vandalism.

C) Potholes in the southwest lobe of Miller Cave should be filled with disturbed on-site sediments or with culturally sterile sediment imported into the site, and another gunnite floor may be prepared for this portion of the cave. This action will protect the Class V deposits in this part of the cave.

D) Floor-to-ceiling and wall-to-wall steel bars (rebar) with 6-inch openings between bars should be inset into the bedrock to create a barrier across the neck of the Southwest Lobe. This action will further restrict access to that portion of the site with greatest integrity and least disturbance.

E) Warning signs should be placed on site to inform potential looters of the site protection measures and penalties for disturbing a site.

F) Information signs should be placed in the main chamber to enhance public education and awareness.

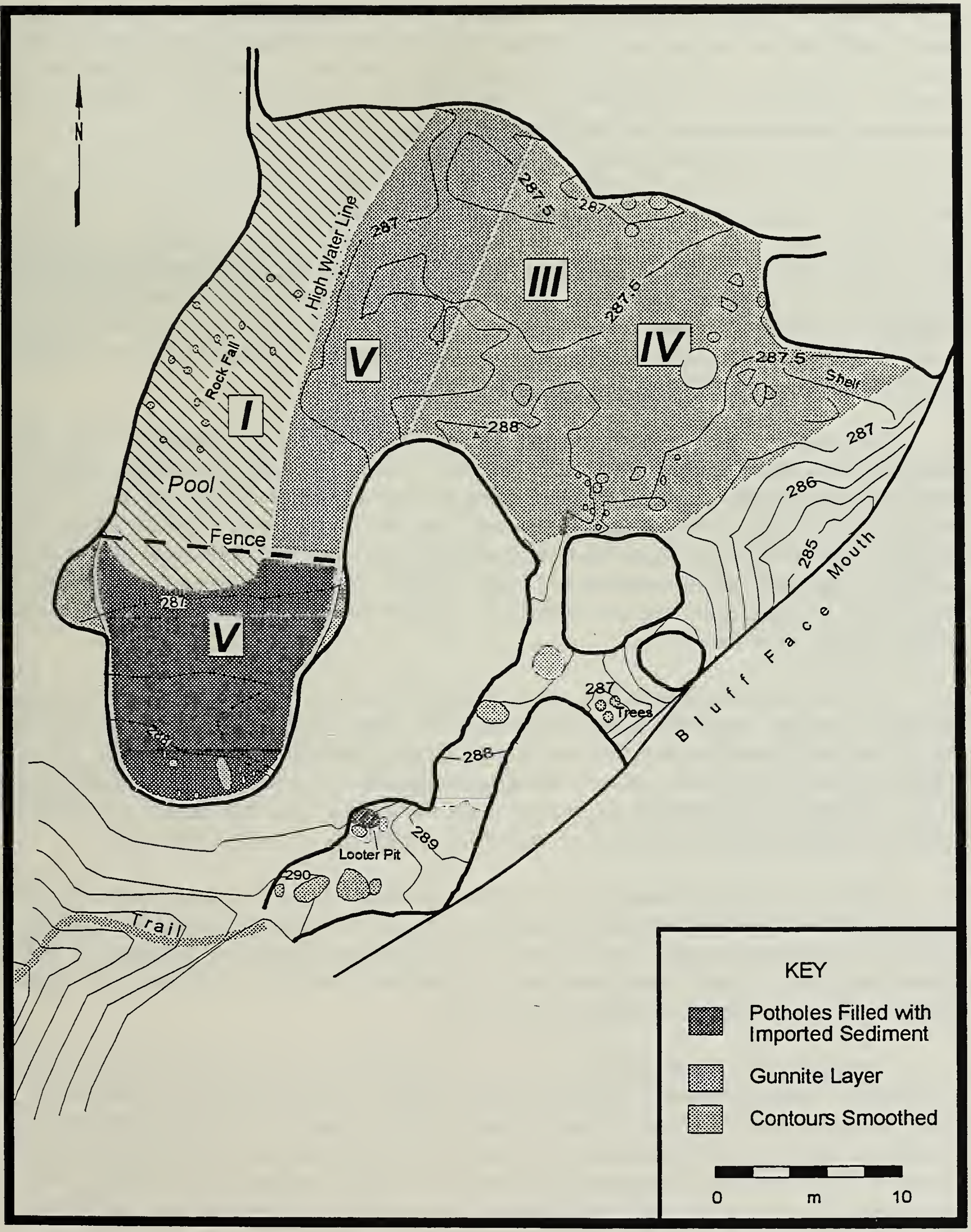


Figure 10. Distribution of Deposits by Preservation Class within Miller Cave and Proposed Site Protection Measures.

These recommendations were incorporated into a proposal for implementing the site preservation plans. This proposal was submitted to the Fort Leonard Wood Cultural Resource Manager for approval. The proposed site preservation plan was funded through a separate grant from the Legacy Resource Management Program which was awarded to WES. Specific aspects of the site preservation plan will be implemented in 1995.

Evaluation of Site Potential

As a result of Markman's (1993) efforts, Miller Cave already has been determined eligible for listing in the National Register of Historic Places. The investigations described here were designed to document the nature and extent of the intact deposits at the site and develop site preservation plans. An underlying goal was to assess the research potential of the site in terms of its current and future contributions to regional prehistory.

The regional research potential and significance of the site is expressed in five research domains. First, Early Archaic deposits are preserved in intact stratigraphic contexts in the vicinity of Markman's Trench 1, and probably all along the southeast edge of the pond as well. These deposits contain both preserved faunal elements (bone and mussel shell) and carbonized botanical remains. Few sites in the region have intact deposits from this time period and almost no Early Archaic components include botanical and faunal remains. Much could be learned regarding Early Archaic settlement patterns, site use, subsistence, and environmental conditions through controlled investigation of these deposits.

Second, it is likely that there is some stratigraphic separation of deposits in the less disturbed portions of the site, especially in the Southwest Lobe. Late Woodland, Late Archaic and Middle Archaic projectile points were recovered from undisturbed deposits in Markman's Test Unit 1, and though no internal strata were defined, stratigraphic separation of components may still be possible. If so, controlled investigations in this portion of the site could greatly enhance our understanding of local and regional cultural chronological sequences and patterns of human adaptation.

Third, the excellent preservation of bone and shell remains and the presence of abundant carbonized plant remains provide an opportunity to reconstruct subsistence patterns associated with specific time periods or strata. These patterns also can be correlated with indicators of settlement system function for specific stratigraphic units or episodes of site use to build and refine settlement system models associated with specific time periods.

Fourth, the site can be utilized as an educational forum to teach visitors about the importance of prehistoric cultural resources on Fort Leonard Wood. Warning signs are necessary to show potential looters that it is illegal to conduct unauthorized excavations. It is also important to have educational and informative signs posted within the cave. Signs could describe the location of Fowke's and Markman's excavations and present a short synopsis of the findings and their importance. Such signage could only help slow the destruction of important sites like Miller Cave.

Fifth, the earlier collections from the site are being curated by the Smithsonian Institution. These collections have never been formally analyzed using modern analytical methods. In addition, the curated site documentation may contain either verbal or photographic records that would enhance

our understanding of the internal site stratigraphy. These collections should be recovered and formally analyzed to enhance our understanding of the site and the general function of large cave sites in the Ozark region.

Implementation of the site preservation plans noted above will more adequately ensure that scientifically significant portions of the site are preserved for future generations. It will also promote better stewardship of the cultural resources on Fort Leonard Wood and serve to educate the public regarding the importance of preserving cultural resources. If research-oriented projects are developed that address any or all of the research domains outlined above, enactment of site preservation plans should ensure the continued existence of intact cultural deposits at Miller Cave.

CHAPTER 6
MILLER PETROGLYPHS

This chapter presents the results of investigations performed at the Miller Petroglyph site (23PU255). A general site description (extracted from Ahler et al. 1995) is presented first, followed by discussion of previous work conducted at the site. Based on this context, site-specific research goals are presented, along with appropriate methodology for reaching these goals. Results of investigations are then presented and interpreted. The final sections present evaluations of the site-specific research goals and our evaluation of the future research potential of the site, based on the current understanding of the site contents and integrity.

Site Description

The Miller Petroglyphs site is located just below the shoulder of the southeast-facing ridge overlooking the Big Piney River valley and Sadie's and Miller caves. The site is a shallow rock shelter, covering an area of about 45 m^2 (Figure 11), with a floor elevation of about 303.4 m asl. Tools and debris are reported on the surface in low densities (Ahler et al. 1995). Twelve large rocks representing roof-fall blocks originating within the shallow shelter form a linear pattern under the overhang. Petroglyphs are found on the sloping, flat, upper surfaces of three of these rocks (6, 8 and 9). The present ground cover near the site is a mixed scrub oak and cedar forest. About 50 m below the shelter is the forested terrace and floodplain of the Big Piney River valley. The Miller Petroglyphs Site is 13 m above the entrances to Miller Cave (23PU2) to the northeast and Sadie's Cave (23PU235) to the southwest.

The rock shelter is in the uppermost tier of a series of shallow shelters that occur on the steep bluff face, and is approached either from the bluff crest above or from below by way of a trail that branches off the steep, winding path leading to Sadie's Cave. The shelter is low, wide and shallow. Maximum dimensions under the drip line are about 2.7 m height, 6.0 m depth, and 32.5 m length. The floor of the shelter is generally flat, with only occasional small patches of soft sediment accumulation; most of the shelter floor is composed of bedrock or large rock fall blocks. The shelter floor continues southeast outside the drip line, forming a narrow ledge (1.0–1.3 m wide) along the entire length of the shelter; this ledge is part of a path leading down to Miller and Sadie's caves from the bluff crest.

Within the shelter are a series of twelve large rock fall block, ten of which were included on the sketch map prepared in 1993 (Figure 11). All of the blocks apparently were dislodged from the shelter roof and fell the short distance to the floor. All of these blocks have a single large, flat surface that was once attached to the shelter roof; this surface is uniformly on the upper, outward-facing side of the blocks. The plane of these surfaces dips between 30° and 50° toward the southeast. An idealized cross section of the shelter is included as an inset in Figure 11, showing the spatial relationships between shelter roof, shelter floor, and the rock-fall blocks.

The petroglyphs are engraved into the flat upper faces of the blocks. Twelve large blocks occur within the shelter, and three of them (Rocks 6, 8 and 9) have petroglyphs or portions of petroglyphs remaining on their upper faces. Rocks 8 and 9 have been severely vandalized. The

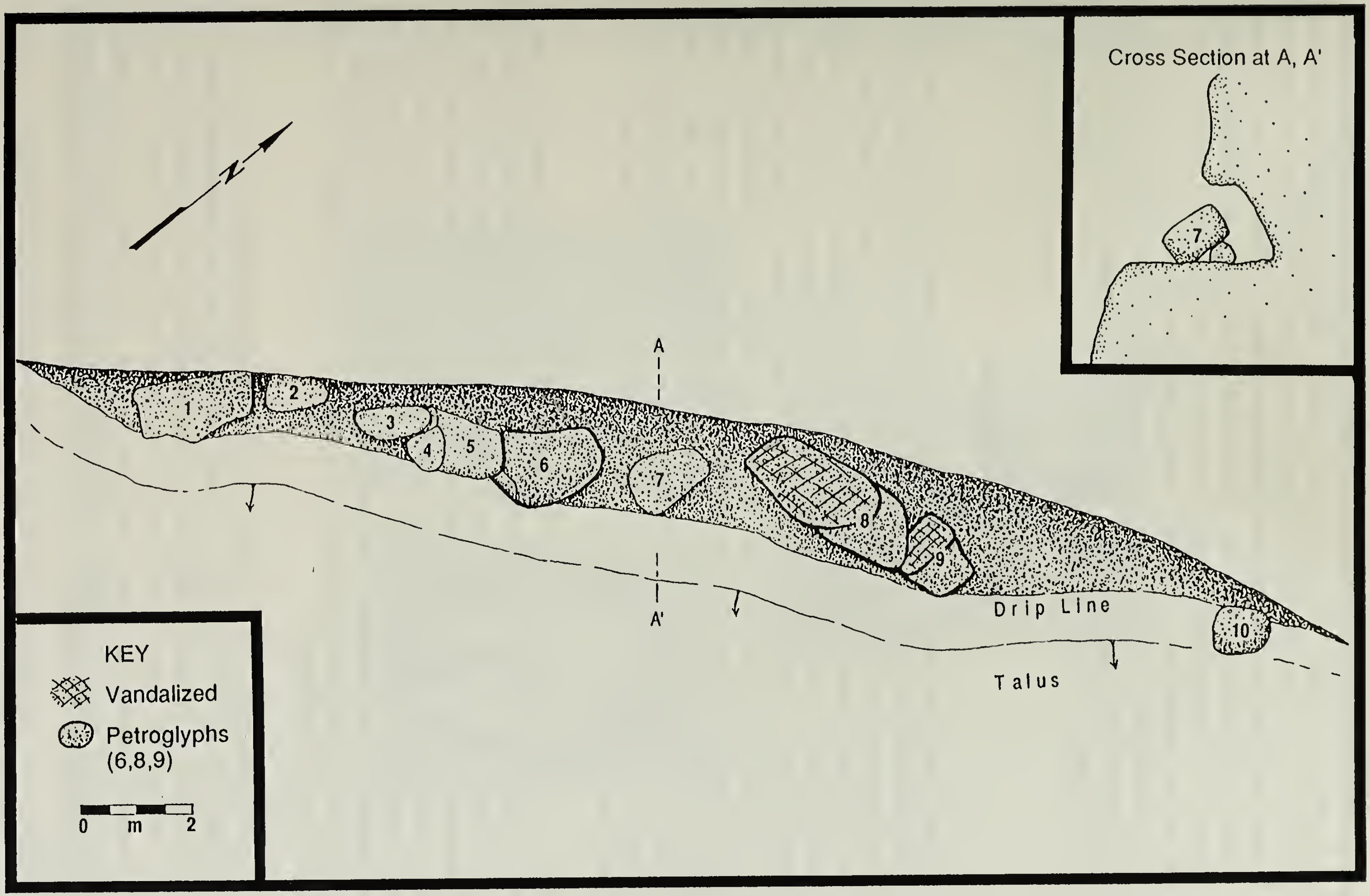


Figure 11. 1993 Sketch Plan Map of the Miller Petroglyphs Site (from Ahler et al. 1995:Figure 20).

upper layer of the thinly bedded sandy dolomite of which the rocks are composed has been dislodged with chisels, removing the images engraved on the surfaces. About 70 percent of the surface of Rock 8 and 50 percent of the surface of Rock 9 have been removed. Rock 6 has been less severely vandalized, but the engravings on this rock have been more adversely affected by natural weathering processes. Because of the vandalism, the site was assessed as being in poor condition. Vandalism is likely to continue in the future unless effective site protection measures can be implemented. One possible reason for the vandalism of the Miller Petroglyphs is that Fowke made mention of these engravings in his description of the general site setting of Miller Cave (Fowke 1922:57–61). In addition, the petroglyphs are adjacent to one of the two paths giving access to Miller Cave, making them a conspicuous feature of the local landscape.

Previous Investigations

The Miller Petroglyphs were first formally described by Fowke (1922:58–61); he interpreted this site as being related to the Miller Cave occupations and briefly described the petroglyphs. One zoomorphic or anthropomorphic figure was observed (Figure 12a), and the remaining 25 or so engravings are rough ovals with openings bisected by straight lines (Figures 12b-c). Leonard Blake photodocumented the Miller Petroglyphs in 1939, and one of his photographs showing the Rock 9 panel face is reproduced by Markman (1993:45). Pippin (1948) provides a photograph, taken in the late 1940s, of the Rock 8 panel showing little damage from vandalism. McMillan (1965) discusses the petroglyphs and makes no mention of the zoomorphic figure described by Fowke; it is also not visible in the Pippin photograph. By the late 1940s, it appears that this figure already had been destroyed or removed by vandals. McMillan (1965:11) provides an excellent photograph of part of the Rock 8 panel face. This photograph shows that as early as 1963, the southwestern 25 percent of the panel had been vandalized.

The site was officially reported to the ASM in 1983 by Niquette. His unpublished site notes describe the condition of the panels in April 1982. By that time, another 25 percent of the Rock 8 panel had been vandalized. At the time of the University of Illinois survey in 1993 (see below), additional vandalism had damaged some of the eastern portion of Rock 8 and about half of Rock 9. The ongoing vandalism of the petroglyphs apparently has not abated with installation of information/warning signs following Niquette's survey. Niquette's field crew documented the site through photographs, but no collections were made. Though there was no interpretation of the NRHP status of the site, field notes and descriptions clearly recognize its unique status as the only petroglyphs on Fort Leonard Wood.

In 1993, the University of Illinois Public Service Archaeology Program conducted a formal Phase II evaluation of the Miller Petroglyphs. These investigations were noninvasive and resulted in photodocumentation of the petroglyph panels, documentation of the condition of the site and production of a sketch map (reproduced as Figure 11). Artifacts recovered from the site did not include any temporally diagnostic items. Only one artifact, a fragment of an expanding stem projectile point, was found. In addition to panel face removal, the 1993 NRHP evaluation documented the presence of numerous historic and recent graffiti that had been carved into or painted on the rock faces.

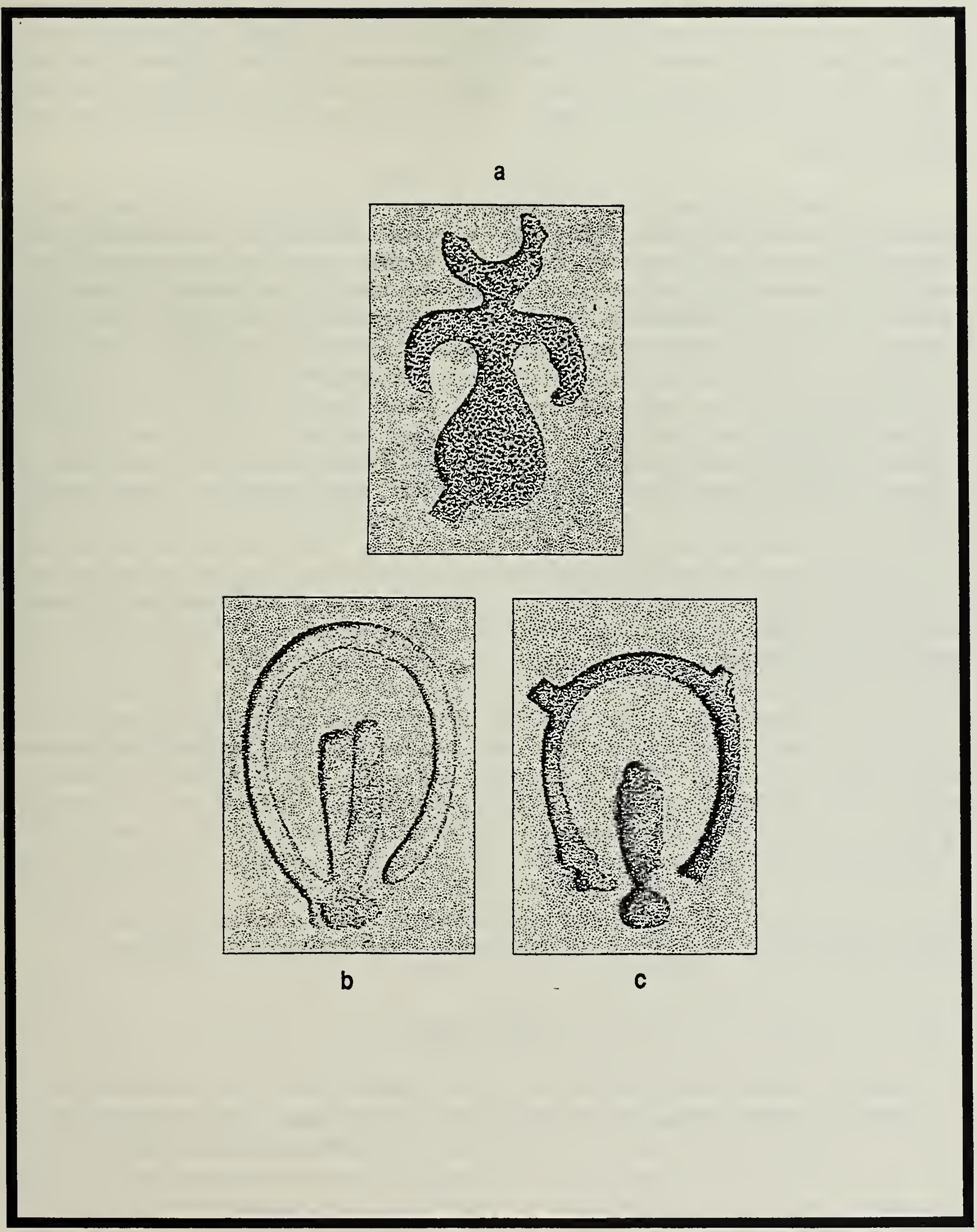


Figure 12. Reproduction of Miller Petroglyphs Motifs Observed in 1920: a, Zoomorphic figure (after Fowke 1922: Figure 11); b-c, bisected ovals (after Fowke 1922: Figure 12).

All of the prehistoric engravings that remain on the rock panels are either partial arcs or bisected ovals. The symbolism of these engravings is at present unclear, and they cannot be tied with decorative motifs affiliated with any particular historic tribe or prehistoric time period. However, Diaz-Granados (1993) has recently completed a study of rock art in the Ozark region. She confirms that many, though not all, of the rock art motifs in Missouri are associated with the late prehistoric period.

In her analysis of these engravings, she isolated several petroglyph motifs that appear to be associated with a wide variety of events, including ceremonial activities associated with child-naming, harvesting, hunting, and related fertility rites. In addition, these motifs may have served as identification markers for clans, territories or natural features of the landscape. Certainly, the bisected ovals bear some resemblance to stylized female and male genitalia, and the juxtaposition of these elements suggests intercourse or fertility-related symbolism. The style and shape of the petroglyphs have been classified by Diaz-Granados (1993) as representing a "vulvar" motif, which occurs in several variants throughout the state. She has interpreted this motif class as representing a female symbol and has suggested that it may be symbolically linked with a female mythological character. These engravings may also have other meanings associated more with their unique position on the Fort Leonard Wood landscape than with either fertility or female mythological characters.

Based on the unique status of the site within Fort Leonard Wood, evidence of ongoing vandalism, and the potential for the motifs to be linked with Late Woodland or Late Prehistoric ceremonial symbolism, the site was recommended as eligible for listing in the NRHP. The Missouri SHPO concurred with those findings in 1994.

The recommendations made for the site in its NRHP nomination recognized that the research potential and scientific significance of the site was contained in the artistic motifs represented at the site. If these motifs could be linked to a particular time period, cultural affiliation or historic tribal entity, it was more likely that the symbolism contained in the engravings could be more meaningfully interpreted. Such reconstructions would make important contributions toward understanding a more complete range of cultural behaviors shared by the prehistoric inhabitants of the region. To retain this research potential in the face of ongoing vandalism, it was further recommended that the rock art motifs be carefully documented and that site protection measures be implemented. The present Legacy project provided an opportunity to accomplish some of these recommendations.

Research Goals

Since the Miller Petroglyphs are badly damaged by vandalism, the main research goal was to record the current condition of the site and the petroglyph rocks. This documentation would include both historic and prehistoric engravings, but would emphasize the prehistoric aspect of the site. These activities were essential to addressing the question of whether this site could be temporally or functionally linked with others in the Miller Cave Complex.

A second goal was to determine, if possible, the temporal affiliation of the petroglyphs themselves, either through stylistic comparisons of the motifs or by dating of associated temporally diagnostic artifacts. No excavations were planned due to the fragile condition of the site.

A third major goal was to develop appropriate site stabilization or protection plans. As with Miller Cave, these plans would have to take into account the fact that the site is easily accessible by the public. It was desirable to preserve the remaining portion of the rock engravings in their present context while still permitting public access to the site.

Research Methods

The focus of the fieldwork was to produce a more adequate record of the site and the rock engravings through nondestructive documentation. Each rock within the shelter would be recorded using a variety of media, including surface rubbings, scale drawings and photographs with and without visual enhancement of the engravings. These activities would document not only the prehistoric engravings themselves but would highlight the damage inflicted on the site. At present, only three rocks contain partially intact engraved faces.

The first aspect of site documentation was to produce an accurate, scale-drawing plan map of the site showing the shelter, rock-fall blocks (both engraved and unmodified) and other salient features of the site. After this plan map was completed, attention would focus on detailed recording of each engraved rock face using charcoal-paper rubbings, scale drawings and photographic documentation with both black-and-white print and color slide film. After documentation of the site and petroglyphs, an attempt would be made to contact local informants who may be in possession of either fragments of the petroglyph rocks or earlier photographs of the site. If these people could be located, they would be solicited to return the petroglyphs as a donation. Finally, local, state and national archives were to be consulted to determine if photographs or drawings of the undisturbed petroglyph rocks were on record. The information obtained in these documentation efforts would be used to develop site preservation options that take into account the present condition of the site, current and past documentation, and potential for future impact.

Results of Investigations

Site Mapping

After establishing elevation and horizontal control points with an electronic theodolite, tapes were used to produce a scale map of the Miller Petroglyph site plan (Figure 13). The major rock fall blocks were numbered from southeast to northwest. Rocks 1–10 were previously identified in the 1993 Phase II investigations; Rocks 11 and 12 were added during this investigation. In addition to the site plan, three cross-section profiles of the rock shelter were constructed using spot elevations and locations established with the theodolite. Sections A, B and C are also included on Figure 13. These maps provide better documentation of the site and can be used as a baseline for determining the extent of present and future damage to the site.

Petroglyph Documentation

The first aspect of petroglyph documentation was to produce a photographic record of the engravings on Rocks 6, 8 and 9 with both black-and-white print and color slide film. One series

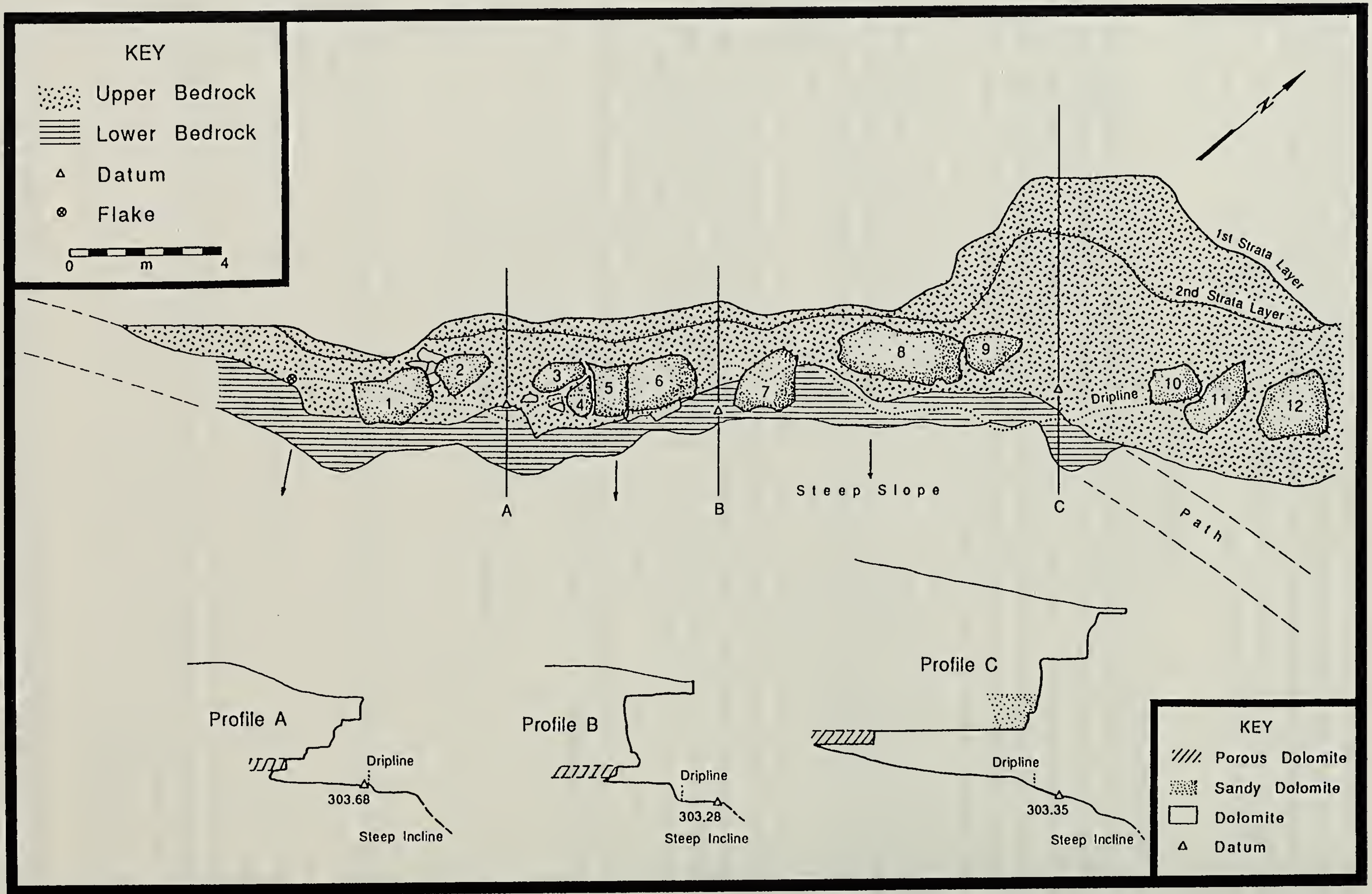


Figure 13. Site Plan and Cross Sections of the Miller Petroglyphs Site. Rocks 6, 8 and 9 have evidence of prehistoric engravings.

of photographs was taken after lightly brushing the surface of each rock to remove dust, leaf litter and dried lichen growth.

The prehistoric bisected oval motifs are probably not engravings in the technical sense; the motifs were most likely pecked into the rock surface instead of being carved by a sharp tool. These activities produced a pitted surface which subsequently has been weathered by natural processes to produce a rough, crenelated and irregular surface. The present surfaces of the prehistoric motifs are often 8 to 10 mm in depth, setting them off in high relief against the smooth, generally flat, unmodified surface of the rock-fall blocks. This weathered appearance of the surface within the prehistoric motifs contrasted markedly with almost all of the historic modifications. The latter were most often true engravings, and most had been carved into the crumbling sandstone with knives or other sharp steel instruments. In a few locations the historic carvings exhibited a rust encrustation at the upper margin of V-shaped grooves. Only a few of the historic modifications appear to have been pecked into the surface, and these surfaces had not weathered as much as the surfaces of the bisected ovals. These differences in both method of modification and degree of weathering permitted prehistoric and historic modifications to be readily segregated.

A second series of photographs was taken after white chalk dust had been brushed onto the deeply pitted surface of the prehistoric engravings to accentuate their location and outlines. Figure 14 (a-b) shows Rocks 6 and 8 with the chalk dust enhancing the engravings.

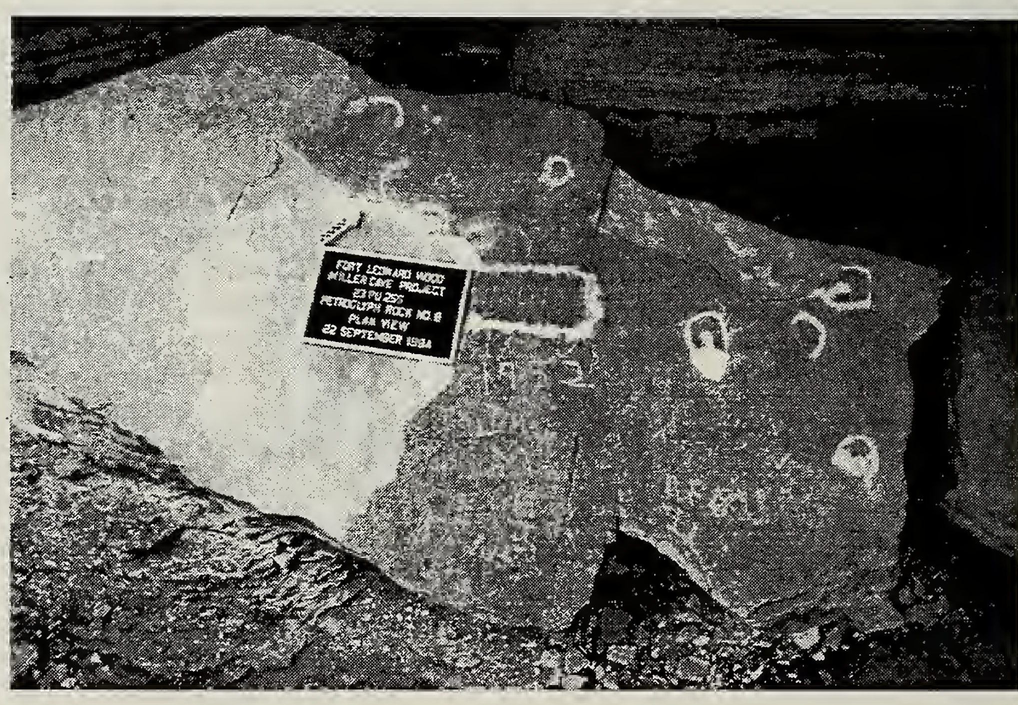
After the photographic documentation was complete, attempts were made to produce surface rubbings of the rock faces using charcoal sticks and tracing paper. The surfaces were too rough to produce meaningful traces of the prehistoric artwork. Some of the historic engravings were readily distinguished, but since these were not the focus of our research, this documentation technique was abandoned.

As a final documentation of the engravings, scale drawings were made of the prehistoric engravings on Rocks 6, 8 and 9. The rock outlines and areas of historic vandalism were included in the drawings, but all historic graffiti and other engravings were omitted. Figures 15 and 16 show the detailed drawings of Rocks 6, 9 and 8, respectively. These drawings and the photographs in Figure 14 clearly document the damage inflicted due to historic vandalism of the rock surfaces. About 50 percent of the surface area of Rock 8 has been removed by vandals. While about 30 percent of the surface area of Rock 9 remains intact, this area includes only two partial engravings; the prehistoric art on this rock has been effectively destroyed. The rock least damaged by vandals is Rock 6, which shows removal of the rock surface in only the northern corner. However, the surface of this rock, especially the southeastern half, is highly weathered. If prehistoric petroglyphs were present in is area, they have been subsequently removed through natural processes. These activities resulted in documentation of six complete engravings on Rock 6, nine partial or complete engravings on Rock 8, and two partial engravings on Rock 9.

Local and Archival Research

To assist in efforts to locate local informants who may either possess fragments of the engravings or older photographs which show the site in a less disturbed condition, the historic graffiti was transcribed from the rocks. The people whose names are carved into the rocks and bluff face, or their descendants, may prove to be valuable sources of information about the site and its former

a



b

Figure 14. Photographs of Miller Petroglyphs Rock 6 (a) and Rock 8 (b) with Chalk Dust Enhancing the Prehistoric Engravings.

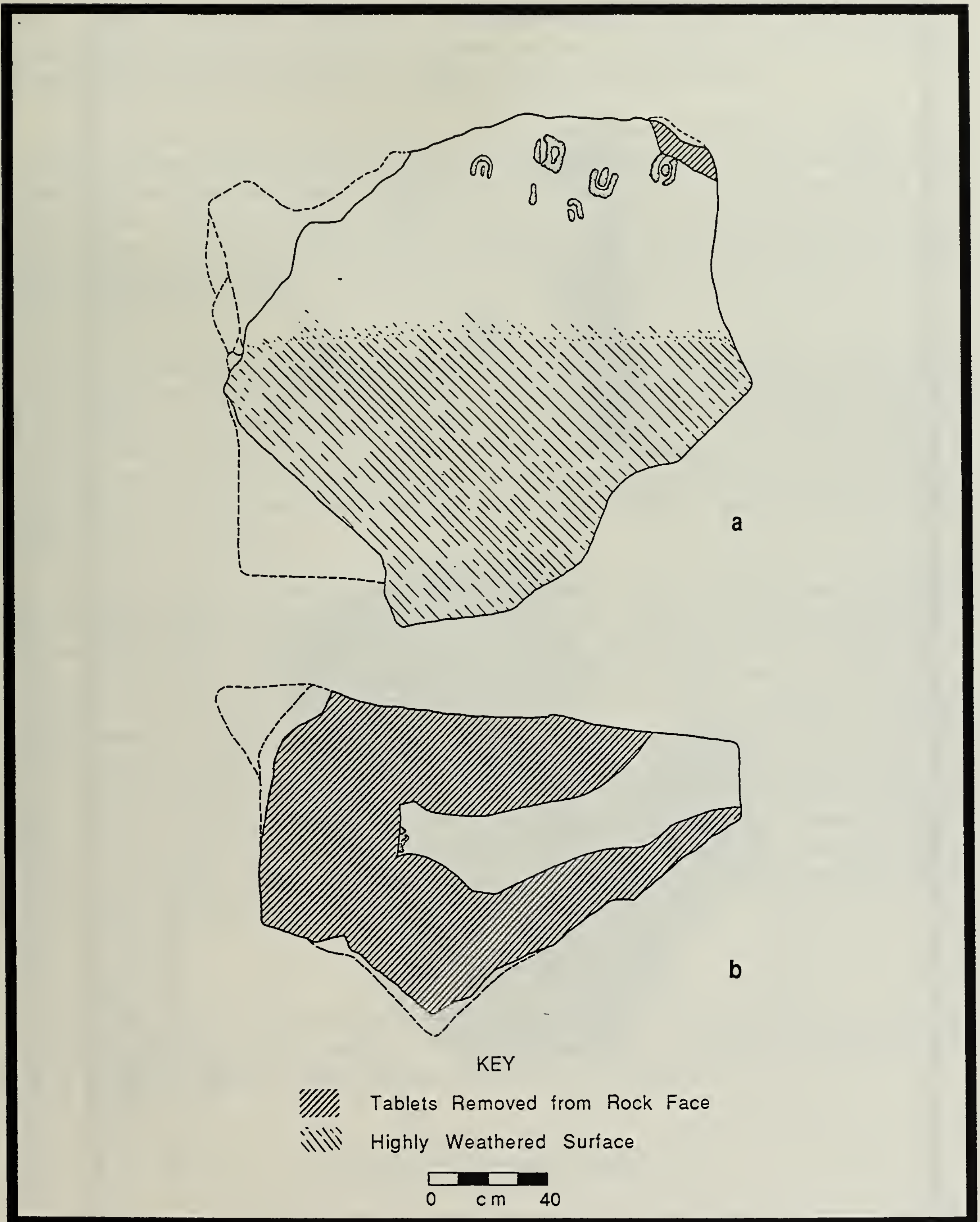


Figure 15. Scale Drawing of Prehistoric Engravings on Miller Petroglyphs Rock 6 (a) and Rock 9 (b).

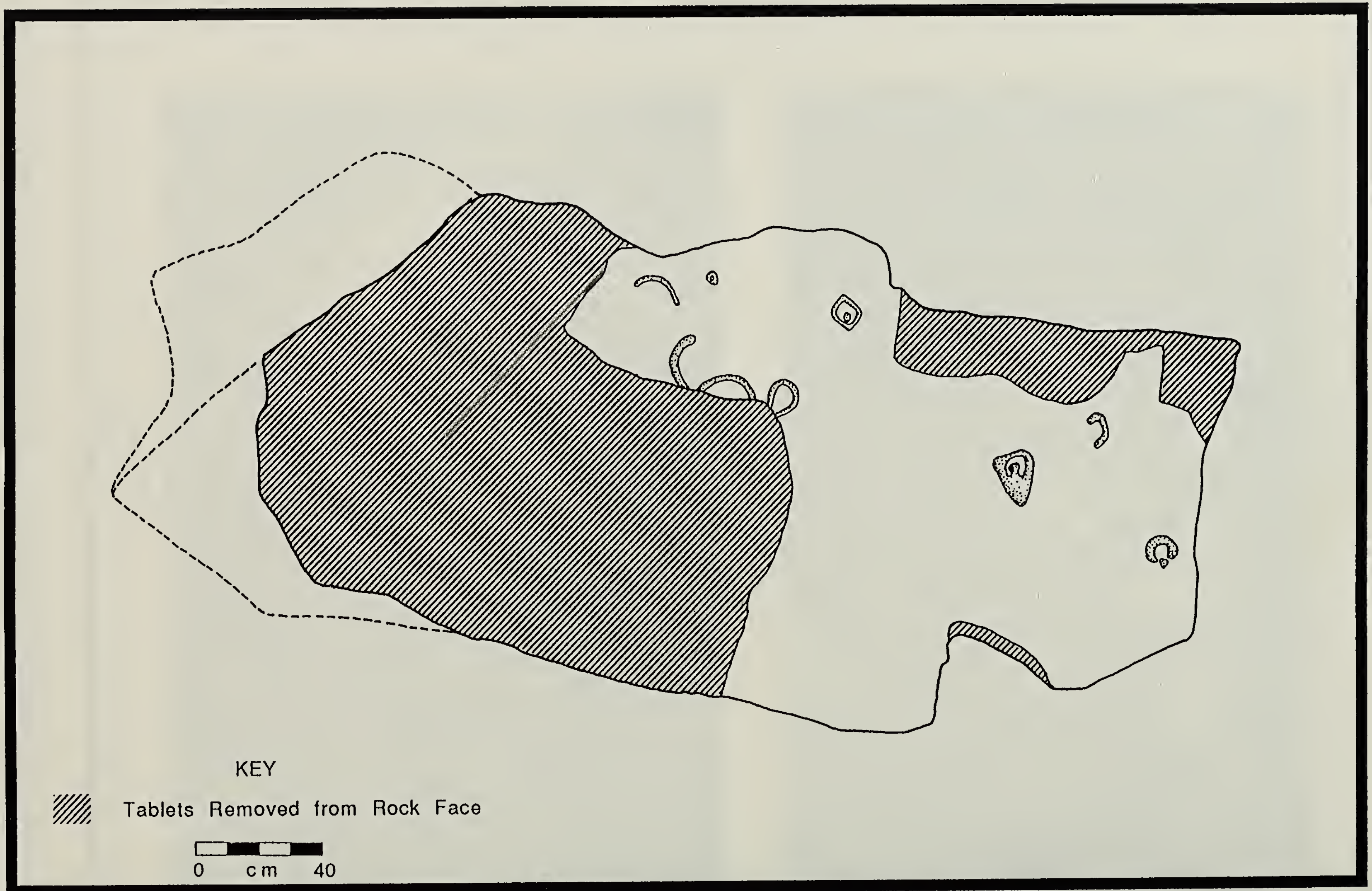


Figure 16. Scale Drawing of Prehistoric Engravings on Miller Petroglyphs Rock 8.

condition. Table 4 presents the historic data that could be extracted from the rock faces and bluff face, along with some notes on possible interpretations and the condition of selected engravings. This information may prove helpful in a systematic search for local informants.

Some general notes of interest include the fact that the face of Rock 8 is virtually covered with historic carvings except where the original face has been vandalized. The inscriptions listed for Rock 8 are those that were decipherable and are listed in general southeast to northwest order on the rock face. There are several undecipherable carvings on the lower, weathered portion of Rock 6 just above the a zone of lichen growth. Finally, several other rocks also may have contained historic or prehistoric carvings at one time, but the severe weathering of these faces has obliterated all recognizable patterns.

A few inquiries were made to local people concerning the names engraved at the site, but little information was forthcoming. None of the local contacts admitted any knowledge of the site or of the prehistoric rock art. It is possible that the families represented in the historic graffiti are no longer in the area; it is also possible that locals were unwilling to talk about this matter to an obviously nonlocal interrogator. It is likely that some fragments of the prehistoric rock art are still in the local area, and in the future, additional efforts should be made to locate these artifacts and any early photographs of the site.

The State Historic Preservation Office had no information on the site other than the published sources already cited (Diaz-Granados 1993; Fowke 1922) and copies of the Archaeological Survey of Missouri site forms that Niquette submitted in 1982. The ASM also had no other information on the site. Diaz-Granados (1994 personal communication) reports that there is another set of petroglyphs on the bluff face below Miller Cave, but these have not been confirmed. She also photodocumented the Miller Petroglyph rock art in 1989, but its condition at that time was similar to the present state of repair. Though it was beyond the scope of the present investigation, one other historic source should be contacted regarding this site. The Smithsonian Institution sponsored Fowke's work at Miller Cave, and he discusses the petroglyphs in relation to the cave site (Fowke 1922:57–61). Though his report contains only line drawings, he may have photographed the engravings as well. If so, these documents should be curated by the Smithsonian, and efforts should be made to obtain prints and/or negatives.

Artifact Assemblage

Only one artifact was recovered at the Miller Petroglyphs. One flake was found on the floor of the shelter (Figure 13). This artifact provides no information on the temporal affiliation of the site or its functional relation to other sites in the Miller Cave Complex.

Evaluation of Research Goals

Earlier, three site-specific research goals were outlined for the Miller Petroglyphs site. The activities reported above have permitted each of these goals to be addressed, and in all arenas, the research has been at least partially successful. Evaluation of each research goal will be discussed below.

Table 4. Transcription of Historic Engravings from the Miller Petroglyphs Rocks and Bluff Face.

Location and Inscription	Comments
Rock 2	
JF 1854	At northwest end, about 10 mm deep
Rock 6	
1877	Preceded by illegible cursive writing
Rock 8	
H + S	
BO	
BI	
Walter G(...)	
NC 1982	
.A. Wilson 1875	
JMP Wilson 1875, was born in 1838	
TM	
RM	
1801	Surrounded by a rectangle; both date and rectangle are battered and heavily weathered surfaces 8-10 mm deep
1952	
J	
ER	
KRII	Or KR11
F. MARION	Serifs on capital letters
John _ _ Wilson	Cursive engraving
MARION	
MOORI(?)NGS 1864	
F MARION	Same style as previous F MARION
WILSON 18__	
Rock 9	
K. 54	On original face
Jill 1972 AU, KI(?)	On recent surface
Bluff Face at Profile A	
J A Wilson, A(?) M Wilson, JMP Wilson	Clean, deep engravings
Bluff Face above Rock 10	
BILL SOHRAPER DEO. 5-65	Probably "BILL SCHRADER DEC. 5-65"

The first goal was to document the site more accurately through construction of detailed site plan maps, photodocumentation of the engravings, production of scale drawings of the prehistoric artwork, and transcription of the historic engravings and graffiti. This research goal was fulfilled, and all of the above tasks were completed. These photographs and drawings provide the most comprehensive and accurate documentation of the site to date. It is unfortunate that at least half of the original number of engravings (25–30) have either been damaged or completely removed by vandals. Only 13 complete and four partial engravings remain.

A second aspect of site documentation was to contact local informants and research state- and federal-level archaeological archives in the hope of producing documentation of the site prior vandalism. Local informants were not forthcoming with information on the site, but this avenue of inquiry was not fully explored. Neither the State Historic Preservation Office nor the Archaeological Survey of Missouri were in possession of any additional information on the site. The curated documents from Fowke's 1920 investigation of the Miller Petroglyphs and Miller Cave may contain early photographs, but this source remains unexplored.

The second goal was to determine, if possible, the temporal and cultural affiliation of the site. This information would allow us to address the issues of temporal and functional relationships among the various sites in the Miller Cave Complex. Unfortunately, only one artifact, a nondiagnostic bifacial thinning flake, was recovered during our investigations. Previous investigations at the site by Fowke (1922), Niquette (in 1982), and the University of Illinois (Ahler et al. 1995) produced only one additional artifact from the shelter surface. This artifact is a proximal fragment of a hafted biface (projectile point) that appears to have had an expanding stem or corner-notched morphology. Again, this artifact is not considered to be temporally diagnostic.

Based on the style of the motifs represented at the site, Diaz-Granados (1993) has concluded that the engravings are probably associated with Late Woodland to Late Prehistoric cultures in the region. However, she has drawn no direct associations between these motifs and any specific historic tribal group. A Late Woodland to Late Prehistoric temporal assignment for the petroglyphs is supported by our observations of the degree of weathering of various pecked and modified surfaces. The bisected ovals are always highly weathered in appearance, and the battered surfaces have been both eroded and more deeply pitted by natural weathering processes that affected them after their placement on the rock faces. The oldest historic date on the rock faces is a date of 1801 pecked into the surface of Rock 8. The pecked surface of the numerals also has a weathered appearance, but is not as deep or as pitted as the surface of the bisected ovals. Most of the later dates are engraved into the surface with steel tools rather than pecked, but one date of 1854 was pecked into the Rock 8 surface and exhibits less weathering than the 1801 date or the bisected ovals. The relative degree of weathering of the pecked surfaces indicates that the bisected ovals were placed on the rocks during the prehistoric era. The fact that these surfaces are not completely obliterated by the effects of weathering suggests placement during the last few hundred years, or during the late Late Woodland period.

The third goal was to use the data compiled above to develop site preservation plans. These plans were designed to preserve the site against the continuing threat of vandalism and at the same time keep the site accessible to the public. This goal was made more difficult because the engraved rocks are in such an exposed, prominent position on the landscape. They are not positioned within a deep shelter or cave that can be effectively sealed against human encroachment. Moreover, a

commonly used trail that provides access from the bluff crest road to Miller Cave passes along the bedrock ledge of the Miller Petroglyphs shelter. It is unlikely that the trail could be obscured or modified to prevent access to this well-known site. Likewise, the configuration of the bluff face, shelter overhang and engraved rocks prevents installation of vertical steel bars that would prohibit access and still permit viewing of the engraved rocks. Bars would have to be slanted outward at the base to avoid impacting the rock-fall blocks, and this would result in a narrower trail that would be very dangerous to traverse.

Given these conditions, the most feasible site preservation plan consists of two integrated courses of action. First, information signs should be placed at and above the site; these would inform visitors of the nature of the site, provide some interpretation of the prehistoric rock art, may perhaps include drawings of the prehistoric engravings derived from Fowke (1922) or the present work, and inform potential vandals of the risks involved in damaging a site protected by federal law and regulations. Second, monitoring of the site should be increased, especially for a few months following installation of the information signs. We have noted elsewhere (Ahler et al. 1995) that installation of warning signs in 1982–1984 apparently attracted attention to the site and resulted in increased vandalism rather than the hoped-for reduction in damage. Perhaps the wording of the signage can be presented as both informative and cautionary at the same time.

Evaluation of Site Potential

An underlying goal of this investigation was to assess the research potential of the site in terms of its current and future contributions to regional prehistory. The Miller Petroglyphs site contains almost no portable artifacts and has very little soft sediment within the shelter. These conditions do not enhance the research potential of the site. Temporal and cultural affiliation cannot be determined through associated artifacts, and the site is unlikely to contain either artifacts or paleoenvironmental data in intact stratified contexts.

The research potential and scientific significance of the site is contained in the artistic motifs represented at the site. If these motifs can be linked to a particular time period, cultural affiliation, or historic tribal entity, it is more likely that the symbolism contained in the engravings can be more meaningfully interpreted. If so, this information could be very important in reconstructing a more complete range of cultural behaviors shared by the prehistoric inhabitants of the region. Even though the precise meanings of the motifs is not presently understood, this site still constitutes a unique cultural resource within Fort Leonard Wood and efforts should be made to protect the site.

At present, there has been little impact to the site from military training, but vandalism has severely affected site integrity. Regardless of the level of military use of the area, the site protection measures discussed above should be implemented to preserve the remaining portions of this unique site. Future investigators may be able to link the site more securely to a specific historic or prehistoric cultural group, but construction of any such linkage will most likely depend on preservation of physical remains in their original context. Photographs and drawings, no matter how detailed, are poor substitutes for artifacts with contextual integrity. Probably the most important aspect of the site preservation plans discussed above is installation of information signs to educate visitors about the importance of the site. Without this increased awareness, vandalism of the site will most likely continue to the point of complete site destruction.

CHAPTER 7
SADIE'S CAVE

This chapter presents the results of investigations performed at Sadie's Cave (23PU235). A general site description is presented first, followed by discussion of previous work conducted at the site (extracted from Ahler et al. 1995). Based on this background context, site-specific research goals are developed and presented, followed by a discussion of the field and laboratory methods. Results of investigations are then presented. Because of the complexity of the excavations and recovery of several material classes that required detailed analyses by specialists, results of investigations are presented in sections that are devoted to discussion of specific site aspects, material classes or research-related analytical topics. Internal site stratigraphy and cultural features are presented first, followed by discussion of chronology. These data are combined to develop analytical units and time-stratigraphic units (strata sets) that are the basis for all subsequent analyses. Later sections present data on sediment analyses and environmentally sensitive material classes (terrestrial gastropods and mussel shell). These are followed by discussion of material classes that contain information relevant to both cultural and environmental patterning (vertebrate faunal remains and botanical remains). Finally, material classes and analytical topics that are most informative of patterned cultural behavior are discussed (ceramic artifacts, lithic debitage, modified items, use-wear analysis, and human skeletal remains). The final sections present integrated discussion and interpretation of the analyses, an evaluation of site-specific research goals, and an evaluation of the research potential of the site.

Site Description

Sadie's Cave site consists of a single tube-type cave chamber that covers an area of about 560 m^2 (Figure 17), making it one of the larger caves in Fort Leonard Wood. This site is recorded on the ASM site form as a large cave, with lithic tools, lithic debris, pottery sherds, bone and shell reported at the surface. The present ground cover in the cave vicinity is a mixed scrub oak and cedar forest with thin understory. Above the cave mouth on the dry shoulder slope is a thin band of hill-prairie vegetation containing cedars and grass understory. Lateral to the mouth of Sadie's Cave and lower on the bluff slope, the ground cover consists of a mesic oak forest and thicker understory of grape vines, greenbriar and other low forbs. Sycamore, elm and ash are prevalent on the lower talus slope, which also forms the northern edge of the Big Piney River valley. Sadie's Cave is about 80 m southwest of Miller Cave and lies at about the same elevation. About 20 m north of the mouth of Sadie's Cave and 13 m higher in elevation is the small shelter containing the Miller Petroglyphs.

The cave entrance faces almost due east (Figure 17) and is approached by way of a steep, undulating, and well-traveled path that follows a ledge along the bluff face. The undulations on the path are caused by accumulation of colluvial sediments in hemicones on the ledge surface below erosional rills or vertical bluff face segments. One of the larger sediment hemicones has developed just northeast of the mouth of Sadie's Cave, and aggrading sediment has partially infilled the cave mouth and eastern third of the cave. Included within these aggrading deposits are the remains of human occupation episodes that took place throughout the Holocene.

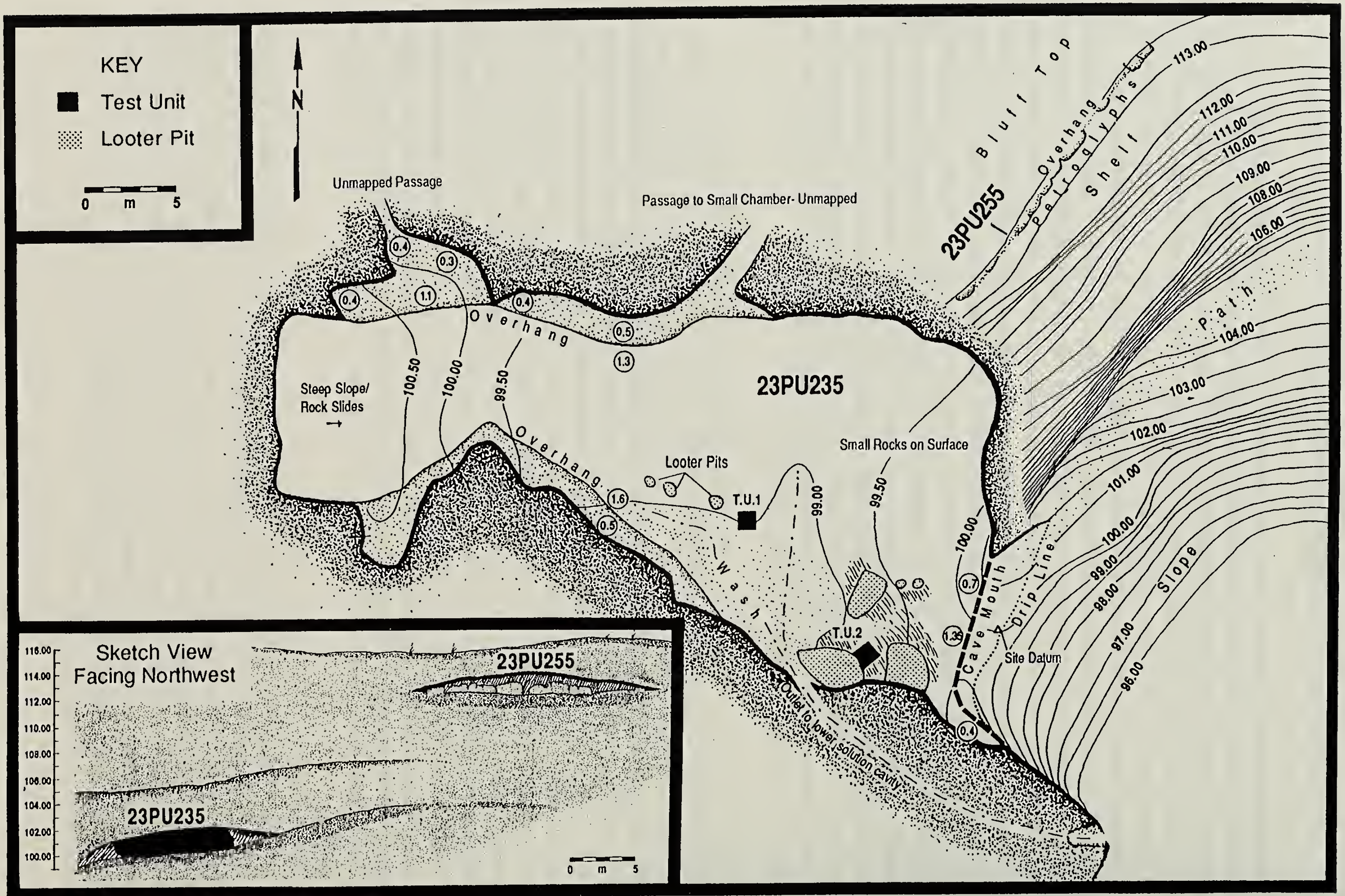


Figure 17. Plan of Sadie's Cave Showing Major Internal Features and 1993 Test Unit Locations.

The cave mouth is low and wide, measuring about 1.3 m in height and 10.0 m in width maximally. The colluvial sediment cone is higher on the north side of the mouth; both soft sediments and large, rock-fall blocks are visible at the surface in this area. The talus slope outside the cave mouth is narrow and steep, truncated about 10 m east of the cave mouth by a vertical bluff almost 30 m in height. The cave interior, a single chamber with two small side passages, measures 40 m east-west and between 7 and 21 m north-south, covering a roughly rectangular area of approximately 560 m^2 inside the drip line. Two unmapped, narrow and low side passages extend at least 5 m to the northwest and north (Figure 17). The north passage eventually opens into a large, low room with standing water on most of the floor. The northwest passage slopes down in a series of steps that were only partially explored. Neither of these side passages was mapped in detail.

Near the cave mouth, sediments are soft dark brown loam to silt loam containing cobble-sized rock fall. These sediments slope down toward the west, indicating that the greatest depth of deposits should be near the cave mouth. In the central part of the cave, floor sediments are reddish-brown clay loam with cobble- to small boulder-sized rocks visible at the surface. This surface is up to 1.2 m lower in elevation than the cave mouth. A sediment cone composed of reddish-brown clay loam and large rock slabs is present at the west end of the cave. The steep slope of this talus cone slants upward to meet the cave roof.

Presence of this type of talus cone indicates that there may have been, at one time, another entrance to the cave from the west that has been blocked by collapse of a sinkhole, forming the internal talus cone. At present, there is no evidence of a sinkhole on the bluff above the cave. This entrance may not have been accessible by humans, but it has permitted periodic water flow through the cave. Continuing, but episodic, internal water flow is documented by the gentle southeasterly slope of the central and western parts of the cave floor and the presence of water-laid reddish-brown clay loam sediment along the south wall. These sediments have been transported within the cave by intermittently flowing surface water, which eventually exits the main chamber through a small crevice in the south wall. This crevice expands, eventually forming a 70-cm diameter solution cavity in the bluff face about seven meters southeast and four meters below the cave mouth.

These episodic water flows have affected the cave taphonomy in several ways. First, it is likely that the sediments infilling the cave mouth from the east were eventually met and truncated by sediments deposited by eastward-flowing water. The present cave surface shows a clear line of demarcation that separates the reddish-brown internal sediments from the darker brown colluvial cone sediments. Second, periodic pooling of water may have occurred along the southern cave wall. Subsequent rapid drainage of the pooled water and short-term higher-energy water flow may have created a steep bank of soft sediments around the pool edge. What was originally interpreted as a looter pit on the south side of the cave may actually represent the rim of this pool area. Third, episodic water flow through the cave would have periodically removed and/or redeposited cultural deposits in those areas with high-energy flow. Especially susceptible to erosion are low-mass deposits such as culturally derived ash, charcoal, bone or shell and naturally derived unconsolidated sediments with low clay content. Some of these sediments and the cultural material they contain may have been either redeposited on the extant cave floor or periodically washed out of the cave by way of the lower solution cavity exit. Based on this reconstruction of the internal cave environment and site taphonomic conditions, it is likely that both intact and redeposited sediments would be encountered during excavations.

Cultural material was differentially distributed on the cave floor. A variety of small flakes, animal bone fragments and gastropod and mussel shell was noted on the sloping surface near the cave mouth. The central part of the cave floor had almost no cultural material, except for a few small pieces of shell. Near the back of the cave large mussel shells and prehistoric ceramics were found on the surface. The distribution of cultural materials on the present cave surface tends to confirm the taphonomic implications discussed above. The cave appears to have been an active environment during the Holocene, with evidence of human occupation potentially removed from the central part of the cave by periodic water flow on the cave surface. The reddish-brown sediments present on the cave floor are probably originally Pleistocene in age, but they may have been reworked and redeposited during the Holocene.

The site is in good to excellent condition, with disturbances limited to a few looter pits in the central and eastern portions of the cave. Two of these pits appear to be fairly recent (Looter Pits # 1 and #2), while several small pits may be decades old. As discussed above, Looter Pit # 2 may represent a natural feature of the cave which has been altered by looter activities. The total area of site disturbance is only about five percent. This low proportion of site damage due to vandalism contrasts dramatically with the situation at nearby Miller Cave, where an estimated 80 percent of the cave surface and volume has been disturbed by a combination of professional and nonprofessional relic collecting (see above and Markman 1993). Vandalism poses the greatest threat to the integrity of 23PU235, since it is easily accessible, near the heavily looted Miller Cave, and located in a portion of the base where access by the general public is not restricted.

Previous Investigations

Initial Documentation (1982)

This site was initially identified by Niquette in 1982 but was not included in his reports because the site lay outside of his contractual survey tracts. The ASM form and field notes for the site describe the cave in general terms, but no internal map was made. The 1982 field crew collected an estimated 10 percent of the artifacts visible on the cave surface; animal bones and shell are noted, and the site is attributed to the Woodland period. No detailed inventory of collected artifacts was included on the ASM form, but field notes indicate that one unidentified shell, four deer bones and 17 sherds were recovered. The ceramics were further described as consisting of four Maramec Cordmarked sherds (two rims and two body sherds) and 13 untyped, sand-tempered, cord-marked sherds (12 body sherds and one rim). The ASM form indicates vandalism had affected about five percent of the site area, and this situation apparently changed little in the subsequent 11 years. Intact cultural stratigraphy is noted, so at least one of the looter pits apparently exposed stratigraphic deposits in its profile. No excavations were performed. Niquette provided no interpretation of the NRHP status of the site, but field notes and descriptions clearly recognize its research potential, especially for the deeper deposits near the cave mouth.

Phase II NRHP Evaluation (1993)

In 1993, the University of Illinois Public Service Archaeology Program undertook formal Phase II NRHP evaluation of Sadie's Cave. Activities performed included surface collection of the cave interior, construction of a topographic map (presented as Figure 17), cleaning looter pit profiles

to expose site stratigraphy, excavation of two test units, and analysis of the recovered material. The following synopsis of Phase II investigations is extracted from Ahler et al. (1995).

Surface collection of the cave interior and external talus slope showed that artifacts were common only in the northwest corner of the cave near the foot of the talus cone. The surface collection produced a total of 70 artifacts, including lithic debris, bone, shell, and sherds. All sherds were recovered from the western third of the cave, and all were assigned to Late Woodland Meramec Cordmarked and Meramec Plain types. No other temporally diagnostic artifacts were recovered from the surface.

To aid in excavation and provide preliminary documentation of deposits in the eastern part of the site, loose sediment was cleaned from the bottom and northern side of Looter Pit #2 (see Figure 17) without benefit of screening. Between 10 and 25 cm of loose backdirt covered an upper intact layer (Stratum 1) of grayish-brown, ashy, gravelly silt. This stratum overlays a layer of lighter brown, more compact silt with small charcoal flecks (Stratum 2). Both intact strata slope down to the west, parallel to the slope of the present ground surface. The artifacts recovered include lithic debitage, bone and shell. A projectile point fragment was found in the cleaned profile wall near the top of Stratum 1. Though it lacked a haft element, it was assigned to the Late Archaic Afton Corner-notched type (Bell 1958; Chapman 1975), based on the angled blade and corner-notch remnant. Recovery of Late Woodland ceramics from the surface and a Late Archaic point near the top of the deposits suggested that Stratum 1 would contain multiple occupations associated with the Late Archaic through Late Woodland periods.

Test Unit 1 was a 1-x-1-m unit placed in the central portion of the site (Figure 17) to explore taphonomic processes and test for the presence of buried cultural strata. It was excavated to almost 80 cm below ground surface in three arbitrary 10-cm levels and one deep exploratory trench. The profile exposed by Test Unit 1 contains four strata (Figure 18a). All are composed of redeposited red clay loam with varying amounts of rock inclusions. No pedogenesis was observed, and human additions to the sediment in the form of artifacts, ash, charcoal, or organic debris are very sparse. Most of the cultural material was derived from Level 2. No temporally diagnostic artifacts were found.

Test Unit 2 was another 1-x-1-m unit placed adjacent to Looter Pit #2 (Figure 17) to take advantage of the exposed profile. The unit was excavated to a depth of 115 cm below ground surface. The entire unit area was excavated to 50 cm below surface in five arbitrary 10-cm levels; levels 6–10 removed the northwest half of the unit. A single flotation sample was taken from the southern corner of Level 11 sediments (100–115 cm below surface). Excavation was stopped after a semiarticulated human burial was partially exposed in the north corner of the test unit at the bottom of Level 10.

The strata in Test Unit 2 (Figure 18b) differ from those exposed in Test Unit 1, and no correlations are possible between the test units. Four strata were defined. Stratum 1 has high ash content in a very dark brown, gravelly loam matrix; artifacts are common. Strata 2 and 3 have fewer artifacts, lower ash content and higher clay content. Stratum 4 is a provisional stratum that was exposed only in the flotation block taken from Level 11. This stratum appears to be more loamy in texture, is structureless and apparently contains less charcoal and artifacts than overlying strata. Neither bedrock nor sterile red clay was reached because of the discovery of human bones.

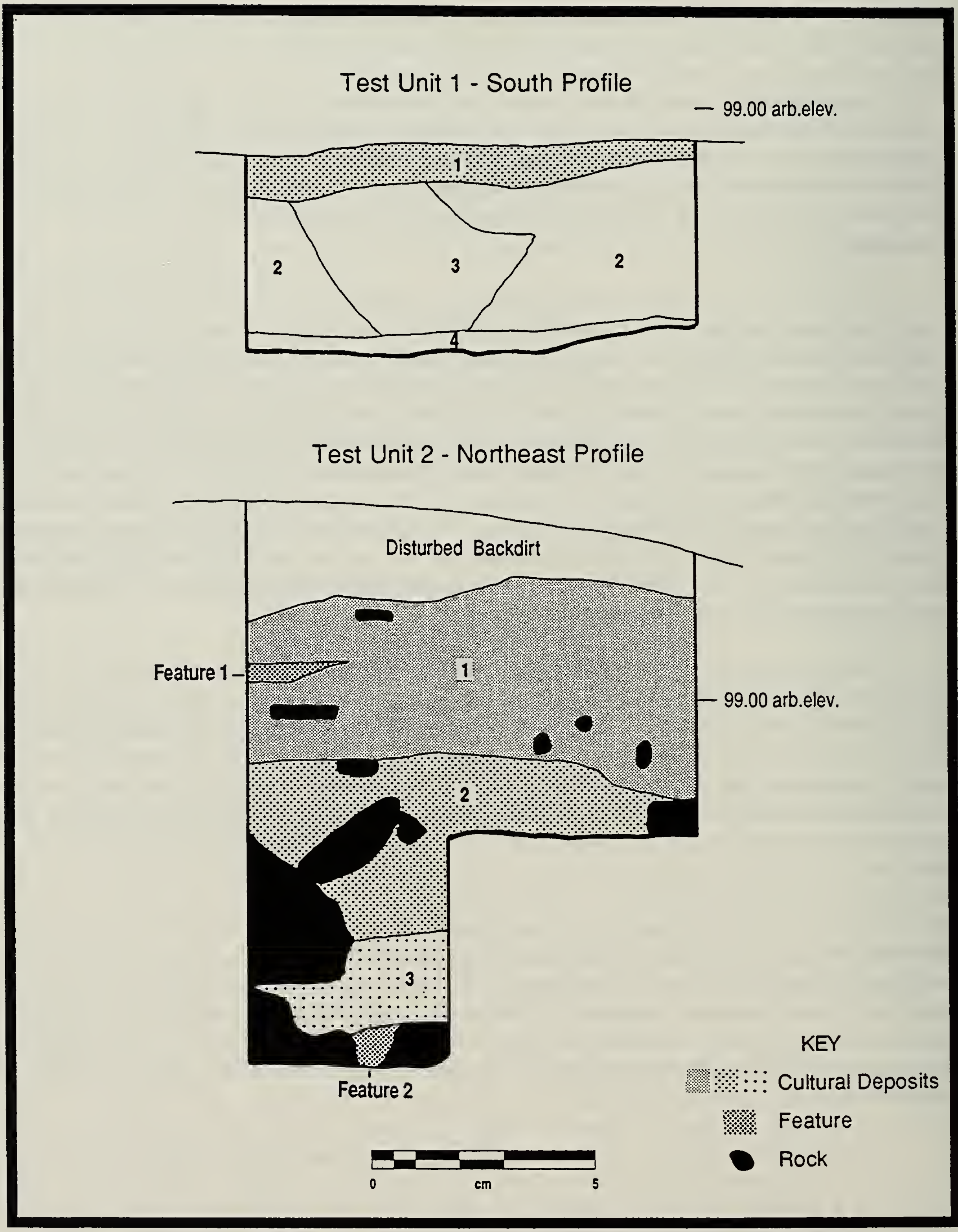


Figure 18. 1993 Test Unit Profiles at Sadie's Cave: a, South Profile, Test Unit 1; b, Northeast Profile, Test Unit 2.

Test Unit 2 contained two features. Feature 1 is a thin, diffuse lens of ash and poorly fired sediment within Stratum 1. The feature may represent a secondary scatter resulting from cleaning a hearth located elsewhere within the cave. Feature 2 is the semiarticulated human burial exposed in Stratum 3. No pit was observed for this burial, and the scattered condition of the elements suggested that the burial may have been moved and redeposited after its original interment. The elements represent an adult; precise age and sex assessment was not possible because critical portions of the skeleton remained unexcavated.

Recovery of a Dalton point from Level 8 (Stratum 3) suggested that the site could contain intact Paleoindian deposits. However, it is known from other sites in the Midwest (see Ahler 1993) that Dalton points were sometimes scavenged by later peoples, recycled or rehafted, and eventually deposited as refuse in later stratigraphic contexts. To establish the depositional integrity of the Dalton point from Sadie's Cave, two radiocarbon samples were sent for assay to the Lawrence Livermore National Laboratory Center for Accelerator Mass Spectrometry. One sample consisted of wood charcoal fragments from Level 8. This sample was divided into two fractions at Lawrence Livermore National Laboratory. The first fraction consisted of carbon derived from humic acids contained in the charcoal fragments, and assayed to 6520±70 B.P. (CAMS-7299). The second fraction was on carbon from the charcoal itself, which produced a date of 6760±80 B.P. (CAMS-7480). Since the means of these assays are only 240 years apart, Level 8 probably dates between about 6,500 and 6,800 years ago. This date range is not in line with the expected date range of Dalton points, and this finding indicates that the specimen from Level 8 was recycled from its original context.

To test for general stratigraphic integrity of the Test Unit 2 deposits, assays were performed on a second radiocarbon sample, which was a large fragment of wood charcoal found adjacent to the right tibia exposed in Feature 2 (bottom of Level 10). This sample was split into two carbon fractions, both of which assayed to 7780±70 B.P. (CAMS-7481 and CAMS-7482). These dates indicate that the lower part of the Stratum 3 deposits, and probably the Feature 2 burial, can be assigned to the early part of the Middle Archaic period.

Based on temporally diagnostic artifacts recovered from stratigraphic contexts and the radiocarbon assays, age ranges were assigned to Test Unit 2 strata. Stratum 1 is apparently late Holocene in age, containing artifacts assigned to Late Archaic through the late Late Woodland periods. The vast majority of the Stratum 1 diagnostic artifacts are sherds indicating Late Woodland occupation episodes; Late Woodland (Rice Side-notched) and Late Archaic (probable Afton Corner-notched) points were recovered as well. Stratum 2 produced no temporally diagnostic artifacts. However, based on assays from Level 8 at the top of Stratum 3, the absence of ceramic artifacts from Stratum 2, and the age range of artifacts recovered from Stratum 1, Stratum 2 was assigned an age range between the late Middle Archaic and the Late Archaic period (ca. 6,500 to 4,000 years ago). Stratum 3 contains artifacts derived from early Middle Archaic period occupations (6,500 to 7,900 years ago), based on the four radiocarbon assays from levels 8 and 10.

The artifact density is greatest for Stratum 1, suggesting that the site witnessed its most intensive use between the Late Archaic and Late Woodland periods. Occupation episodes may have been quite variable during this time span, and may have included use of the site as a base camp, specialized processing site, short-term residential camp, or ritual-activity site at different times. Stratum 2 expressed the lowest density of lithic and bone artifacts. The lower density of artifacts

suggests that use of the site was limited during this period. Artifact and bone diversity values are also lowest for this stratum. Collectively, these attributes suggest that Stratum 2 contains a series of short-term occupations of limited duration rather than the remains of generalized long-term occupation. Stratum 2 occupations probably do not represent the remains of base camps. Stratum 3 contains artifacts indicative of a wider variety of activities than Stratum 2, suggesting a longer duration of occupation or broader range of activities, similar to what would be expected from a more generalized occupation or series of occupations. Lithic debitage and tools include a variety of morphological categories, and a diverse set of taxa is represented in the vertebrate faunal assemblage. Use of the site as a base camp or longer-term generalized habitation is consistent with regional trends in prehistoric settlement systems that document initial development of long-term base camps near the beginning of the Middle Archaic period (see Ahler 1984; Ahler et al. 1991; Brown and Vierra 1983; Brown 1985; Wiant et al. 1983).

The Phase II investigation of Sadie's Cave indicated that the site is multicomponent, with Late Woodland, Late Archaic and Middle Archaic occupations preserved in largely intact stratified deposits. While Stratum 1 represents a range of time periods, strata 2 and 3 appear to be more limited in duration, representing occupations during the late and early parts of the Middle Archaic period. Even though Stratum 1 is culturally mixed, all materials are associated with late Holocene occupations; analysis of these remains can provide important information on paleoenvironmental conditions even though individual cultural occupation episodes are not distinguishable. Investigation of the deposits can also enhance our understanding of local chronological sequences, paleoenvironmental trends, and patterns of human-land interaction through time. An alternative interpretation of the Sadie's Cave Test Unit 2 deposits is that all of the sediment contains the remains of repeated short-term occupations that took place over the span of several thousand years. Even if this is the case, the deposits in the eastern third of the cave are demonstrated to have stratigraphic integrity and to contain evidence of human occupation and associated faunal and botanical remains.

Based on the results of the Phase II investigations, Sadie's Cave was nominated under Criterion D to be eligible for listing in the NRHP. In 1994, the Missouri State Historic Preservation Office concurred and determined that the site was eligible for NRHP listing. Sadie's Cave contains fairly deep, stratified Holocene deposits that are of considerable significance for regional research issues. Moreover, the site contains a largely undisturbed stratigraphic record with little evidence of vandalism. The site has apparently not suffered the fate of the other large caves documented within Fort Leonard Wood. However, the 1993 site evaluation also recognized that the site was at considerable risk for sustaining damage from looters. As a consequence, the recommendations developed for Sadie's Cave included installation of site protection measures and also implementation of a program of intensive, research-oriented test excavations that would document the site before it was destroyed (Ahler et al. 1995). The present Legacy Program research was a direct development of these recommendations.

Research Goals

The Phase II investigations in Sadie's Cave established the scientific significance and importance of the site to regional prehistoric research. The stratigraphic sequence documented in the eastern part of the cave was interpreted as being similar to the sequence of occupation that was once contained within the nearby Miller Cave. Most of the stratigraphic integrity of Miller Cave has

been destroyed through previous excavations, but the Sadie's Cave stratigraphy is almost completely intact. Sadie's Cave has not been impacted to the degree of the other large caves at Fort Leonard Wood; vandalism has affected less than five percent of the cultural deposits. However, it was thought that severe damage eventually would be inflicted on the site by vandals or relic collectors.

Under the circumstances described above, Sadie's Cave represents a scientifically significant site that is continually at risk of destruction or damage. Moreover, it contains a nearly complete, intact Holocene stratigraphic sequence that expresses a record of both cultural and paleoenvironmental changes spanning the Holocene. These attributes make Sadie's Cave a rare and potentially unique site, given what is known of the present condition of other large caves on the Fort Leonard Wood property. These circumstances led to a decision to continue an expanded program of test excavations at Sadie's Cave, with the goal of obtaining and analyzing a larger sample of cultural and paleoenvironmental data from intact stratigraphic contexts before the site was severely damaged. The present Legacy project provided an opportunity to collect and analyze these data. As with the other sites in the Miller Cave Complex that were investigated through this project, site stabilization or preservation plans were to be developed, based on the results of the field investigations and laboratory analyses.

A series of site-specific research goals was developed, based on the potential of the site to address a variety of regionally important research domains that had been previously identified in the Fort Leonard Wood Historic Preservation Plan (Harland Bartholomew and Associates 1992), the Missouri Master Plan for the Gasconade Study Unit (Weston and Weichman 1987), and regional archaeological syntheses provided by Reeder (1988) and Chapman (1975). Ahler et al. (1995) identified five research goals that were relevant to Sadie's Cave, and another goal was developed specifically for the present Legacy project. These research goals focus on the potential of the site for refining local chronological sequences, contributing to paleoenvironmental reconstructions, and developing models of local settlement and subsistence systems. Seven research goals were developed that could be addressed through the present project.

First, Late Woodland cultural material was recovered from the Sadie's Cave surface and from Test Unit 2/Stratum 1 deposits, indicating that the site witnessed extensive use during this time period. However, the function of the site during the Late Woodland is unknown, and efforts would be directed to determine the role of this site in the local Late Woodland settlement system. There are some suggestions that cave sites may have functioned as specialized burial locations during this period, with general residential habitation restricted to open sites in floodplain settings (Markman 1993). Analysis of lithic, bone and plant remains from the upper strata of deposits should provide the means for making an interpretation of Late Woodland site function and testing the hypothesis that the site was used as a specialized burial location.

Second, the stratigraphic separation of deposits in the eastern third of the cave provides an excellent opportunity to build and test local and regional cultural chronological sequences. Additional radiocarbon dates associated with temporally diagnostic artifacts are sorely needed in the Ozark region, and this site contains both diagnostic artifacts and datable carbonized wood remains in sealed stratigraphic contexts. In addition to providing an overall contribution to regional chronological sequences, stratigraphically controlled radiocarbon samples from various strata in Sadie's Cave will provide internal temporal control of components and allow for construction of internal time-stratigraphic units that will greatly enhance other aspects of the analyses.

Third, the excellent preservation of bone and shell remains and the presence of carbonized plant remains in some abundance provide an opportunity to reconstruct subsistence patterns associated with specific occupations or strata. These patterns can be correlated with other indicators of settlement system organization (lithic production, density and diversity data for modified item classes) to develop and refine interpretations of specific episodes of site use and to refine models of changing settlement system organization through time.

Fourth, major stratigraphic divisions within the site span the mid-Holocene, a time period generally thought to have been affected by regional climatic conditions that were warmer and possibly drier than those of today. Preserved bone, shell and carbonized plant remains can be analyzed for indications of paleoenvironmental and paleoclimatic conditions. Paleoclimatic indicators include clinal size variation of white-tailed deer, clinal size variations of selected terrestrial gastropod species, identification of species that are outside their present range and adapted to drier conditions, species composition of plant remains, and habitat preference data derived from analysis of mussel shells. These paleoenvironmental indicators can be combined to provide a baseline data on local environmental conditions and how these changed or remained stable through time.

Fifth, human responses to the impact of the mid-Holocene drying period (Hypsithermal Interval) may have included population aggregation in favorable landscape settings, development of more logistically organized settlement systems, changes in technological efficiency as a result of decreased group mobility, and changes in dietary preferences. All of these possible human cultural responses to changing environmental conditions can be investigated through analysis of the cultural remains preserved in Sadie's Cave. Specifically, information on site function, settlement system organization and baseline paleoenvironmental data can be combined to test some of the hypotheses presented by Wood and McMillan (1976) and McMillan and Klippel (1981) regarding the impact of the Hypsithermal on central Missouri human populations and adaptive strategies.

A sixth research goal was to investigate and define more completely the temporal and functional relationships between Sadie's Cave and other sites in the Miller Cave Complex, especially Miller Cave itself. Specifically, the temporal periods represented in both Miller and Sadie's caves would be compared, and the function of each site in the local settlement system would be compared for each common temporal period or component present at both sites. This information would enhance our understanding of Early Archaic, Middle Archaic and Late Woodland settlement systems and would contribute to our understanding of the Miller Cave Complex as an archaeological construct or as a real feature of the prehistoric settlement system.

Finally, the seventh research goal was to develop site stabilization and protection plans that would preserve this important site against potential vandalism. Specific portions of the site may prove to contain extremely important and regionally significant stratigraphic sequences. If so, these areas should be identified as high priority for preservation efforts. Implementation of the site preservation plans would have to be deferred to a later date, but this project would develop specific preservation targets.

Research Methods

Field methods generally followed those employed in the 1993 Phase II test excavations at the site (see Ahler et al. 1995). Laboratory methods were expanded to permit analysis of a larger sample of materials by various specialists. The general field and laboratory methods are discussed below; specialized analytical techniques employed in the analysis of specific material classes are discussed in the appropriate analytical sections.

Field Methods

The first task in the fieldwork was to establish mean sea level elevations for the site. An open traverse was run from a spot elevation on the bluff crest to the 1993 site datum located at the mouth of the cave flush with the ground surface. The 1993 datum (arbitrary elevation of 100.00 m) has a true elevation of 289.78 m asl. Other internal elevations were calculated using this tie-in point. Figure 19 still shows the 1993 arbitrary elevations and contours, but some spot elevations of interest are listed as follows:

1) Northeast corner of test units 4 and 5 has elevation of 289.70 m asl;

2) East corner of test units 2 and 6 has elevation of 289.18 m asl;

3) East corner of Test Unit 3 at ground surface has elevation of 288.84 m asl;

4) East corner of Test Unit 7 at ground surface has elevation of 288.66 m asl

To collect a larger sample of artifacts and environmental indicators that would permit us to address the research goals stated above, five additional 1-x-1-m test units were excavated in the eastern third of the cave (see Figure 19). This area contains documented stratified cultural deposits at least 1.1 m deep, and these deposits were expected to be considerably deeper near the cave mouth. Wherever possible, looter pit profiles or other exposed stratigraphic series were used to guide stratigraphically controlled excavation of adjacent test units. The test units were placed to maximize stratigraphic separation of deposits as well as interunit stratigraphic comparisons.

Excavation normally proceeded in arbitrary 10-cm levels, but when natural or cultural stratigraphic boundaries were observed, the stratigraphic breaks took precedence in defining excavation levels. All excavated sediments were screened through 6.35-mm (1/4-inch) mesh hardware cloth, facilitating recovery of lithic artifacts, debitage, and bone and shell remains. Standard flotation samples of 10 liters each were extracted from each level. When cultural features were defined, these were excavated separately from the general sediment matrix, and first priority was given to obtaining flotation samples from any fill zones within the feature. Remaining feature sediments were screened. Flotation samples provided a sample of carbonized botanical remains that were analyzed for data on prehistoric subsistence and environmental conditions. In addition to the flotation samples, carbonized plant remains were hand-collected during excavation of features and levels. These hand-collected samples have no volumetric control and are of limited use in analyzing statistical trends in plant use or subsistence changes through time. The hand-collected carbon samples provided the majority of the carbonized material that was sent for radiocarbon assay.

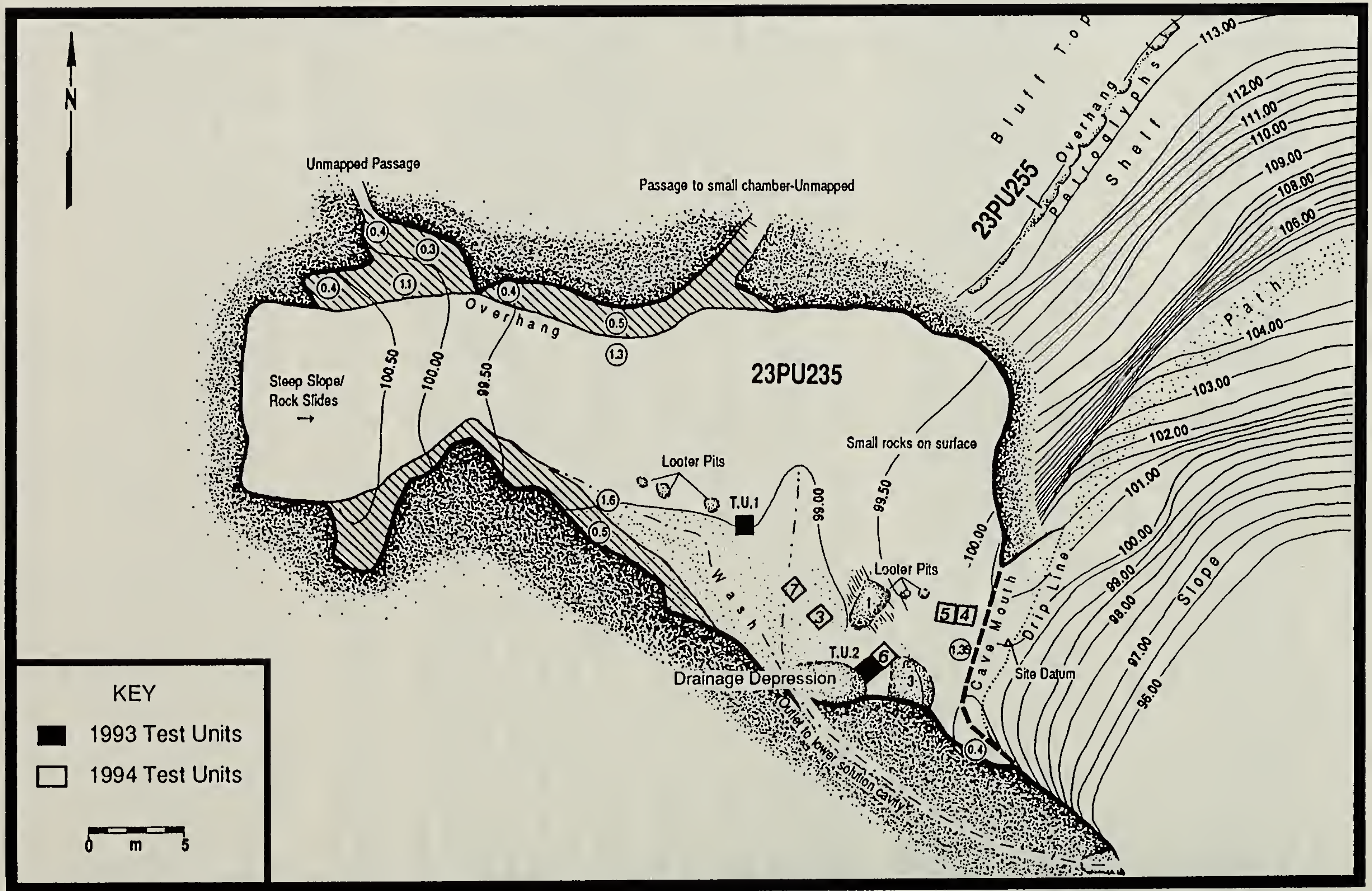


Figure 19. Location of 1993 and 1994 Test Units in Sadie's Cave.

All test units were excavated to culturally sterile sediments, and at least two adjacent profiles from each test unit were drawn at 1:10 scale and photographed in both black-and-white print and color slide film. Strata within each test unit or adjacent pair of test units were defined independently of the stratigraphic sequence observed in other test unit locations. Strata were defined based on changes in texture, structure, compaction, color, and the relative amount of inclusive material such as ash, charcoal, artifacts, and rock of various size classes. All major strata and minor subdivisions within each stratum were described using standard ASCS soil/ sediment terminology and comparison of moist sediment to standard Munsell soil color chart chips. Soil samples (0.3 liter volume) were taken from all major strata and some of the minor strata subdivisions for later chemical and particle size analyses. In addition, five-liter bulk sediment samples were extracted from the each of the major strata exposed in Test Unit 5, which afforded the deepest stratigraphic series at the site. These samples were used to extract and analyze terrestrial gastropods, which are useful paleoenvironmental indicators. Test units were backfilled to original contour upon completion of excavation; empty film canisters mark the corner of each test unit.

Additional documentation of the excavations was provided through field forms, drawings and notes. A level form was completed for each excavated level, and feature forms documented each feature that was recognized during the course of the excavations. These features were given feature numbers in the sequential series that was started in the 1993 testing project. Features 2 through 9 were recognized during excavation, and at least one flotation sample was extracted from each documented provenience. Some features were recognized as such only in profile after excavation had been completed. These were numbered from Feature 101 through Feature 119. Because they were recognized in profile after partial excavation, not all 100-series features have an associated flotation or screened sediment sample. Provenience data for all excavation units, levels, features, and samples were maintained in a field number catalog. The bag number is the key to provenience data in the curated collections. The site director kept a daily field log that summarized activities and provided ongoing interpretations of features, cultural components and stratigraphy. Other crew members made supplementary notes pertaining to their respective levels and test units. All notes, records, drawings, photographs, and other documentation of the fieldwork are curated with the artifact collections.

A single block of contiguous test units was not viewed as an appropriate excavation strategy at Sadie's Cave because of the high probability that stratigraphic sequences in the cave environment would change rapidly over the space of a few meters of horizontal distance. More appropriate for these conditions was excavation of a series of isolated test units, separated by spaces of two to four meters, that collectively provided stratigraphic profiles of the eastern cave deposits. The 1994 excavations resulted in completion of Test Unit 2 (started in the 1993 Phase II testing) and complete excavation of test units 3–7 to the top of culturally sterile residuum deposits.

Excavations began with removal of backdirt from Test Unit 2, after which the remaining portions of levels 6 through 10 were excavated from the southeastern half of the unit. This action provided sufficient exposure of the Feature 2 burial to determine its orientation and completeness. Portions of the test unit floor that were part of the burial or any associated grave were to be pedestaled and left unexcavated. In areas of the test unit that were not included in the burial or grave, excavation would continue until culturally sterile basal deposits were encountered. The burial, while potentially informative with regard to dietary, demographic and genetic research issues, was viewed as a potential source of concern. Accordingly, and with particular regard to the provisions

of the Native American Graves Protection and Repatriation Act (NAGPRA) and Missouri Statute 194.400–410, it was determined that the burial would not be excavated or removed unless it was absolutely necessary for completion of the test unit and realization of the overall project goals.

However, exposure of the Feature 2 burial showed that it covered the entire floor area of the test unit. There was no area that could be excavated to culturally sterile sediments while leaving the remainder of the feature intact. After consultation with the Missouri State Historic Preservation Office, the Fort Leonard Wood Cultural Resource Manager and Dr. Marie Cottrell, an administrator for Legacy projects, it was decided that the burial would be excavated to facilitate fulfillment of the general research goals of the project. One of the key factors in this decision was that Feature 2 was interpreted as an isolated burial and not part of a formal cemetery. The skeletal elements and associated grave goods were carefully exposed, the burial was drawn and photographed in several stages of exposure, and the remains were finally removed and wrapped in protective batting for shipment to the University of Illinois, where final washing and osteological analysis was completed. The burial is more fully described in the section below devoted to features, and the osteological analyses are presented in another section.

After the Feature 2 burial was removed, Test Unit 2 was excavated to expose culturally sterile residuum deposits over the entire floor surface. After documenting the exposed stratigraphy, the 1-x-1-m unit adjacent to the northeast (Test Unit 6) was opened to provide a larger sample of cultural material from this portion of the site. The strata exposed in the northeast profile of Test Unit 2 were used as a guide for the removal of Test Unit 6 sediments in a combination of natural and arbitrary 10-cm levels. The strata in Test Unit 6 were numbered to conform to the strata already described in Test Unit 2; the profiles differed only in the presence or absence of minor substrata.

Also of particular interest was excavation of test units 3 and 7, which were placed between 1993 test units 1 and 2 (Figure 19). Test units 1 and 2 yielded completely different stratigraphic sequences that could not be correlated, reflecting the divergent sedimentation and taphonomic processes operating in the eastern and central parts of the cave. Test units 3 and 7 were placed to provide information on the area of interface between these processes. In addition, these units permitted stratigraphic correlations to be drawn to link the original test units. These test units were excavated in a combination of arbitrary and natural levels that were parallel to the original ground surface to maintain the slope of the strata.

Two contiguous test units (4 and 5) were placed near the mouth of the cave with the east edge about 1.2 m west of the drip line, in an area that was likely to contain the deepest stratigraphic sequence of deposits. This location was chosen to provide the best possible stratigraphic separation of time periods and potentially contribute most to our understanding of changes in cultural manifestations and paleoenvironmental expressions through the Holocene. Test Unit 4 was started first and was excavated in arbitrary 10-cm levels because of the absence of exposed stratigraphy to guide the excavations. A partial human skeleton consisting of articulated lower leg and arm bones was exposed at the bottom of Level 6. Level 7 exposed the bones enough to establish the location and orientation of the remains. Unlike Feature 2, this burial (Feature 3) covered only the eastern portion of the unit, with the remainder of the skeleton extending into the east and south (?) walls. After profile documentation and feature documentation, the unit was closed and partially backfilled. The 1-x-1-m unit immediately west of Test Unit 4 was opened and designated as Test Unit 5. Excavation of the upper portion of Test Unit 5 was facilitated by the strata exposed in the Test Unit

4 profiles. Test Unit 5 was excavated in a combination of natural and arbitrary levels to a depth of about 1.6 m below original ground surface (Level 17).

After profile documentation was completed for all test units, each unit or contiguous pair of units was backfilled. Film canisters were used to mark the deep corners of the excavation units.

Laboratory Methods

The first task conducted in the laboratory was to describe and define stratigraphically robust analytical units that could be used as a common basis for conducting all detailed analyses of major material classes. The profile drawings were examined and level-strata correlations were made for all recorded proveniences and samples (bag numbers). Volumetric data were calculated and recorded for each excavated level. Each carbon sample, general screen-recovery sample and flotation sample from every level and feature was assigned to a specific stratum or combination of strata that had been defined for each test unit. For the vast majority of sample proveniences, the field determination of stratigraphic association was correct, but some stratigraphic associations were changed after the level elevations were compared in detail with the profile drawings for each test unit. Using the strata-level correlations, analytical units were established which represent unique combinations of major strata or sampled cultural features that occur within each isolated test unit or contiguous pair of test units. At this stage in the analysis, no attempt was made to correlate strata among the physically noncontiguous test units. More inclusive interunit comparisons were made after the internal site chronology was established through radiocarbon assays. The bag list information and associated strata, analytical units and sample volumes are listed in Appendix C. This task was performed by the Project Director, and it forms the common basis for all subsequent analyses.

The second major task for the laboratory was to select hand-collected carbon samples for radiocarbon assay. All hand-collected samples were air-dried in the laboratory and hand sorted, separating the carbonized plant remains from the sediment matrix. Samples were not floated in water or chemicals. The separated carbonized plant remains were weighed, assessed for their general contents (wood charcoal, carbonized nutshell or a mixture of both) and stored in clean aluminum foil pouches. Field notes and forms were examined for information that would indicate disturbed contexts of specific samples; when found these samples were identified and marked as potentially disturbed. Based on these data, each hand-collected sample was given a letter grade that expressed the quantity and quality of the sample. Grade A samples massed more than 2.5 g of mixed wood charcoal and carbonized nutshell or more than 3.5 g of wood charcoal. Grade B samples massed 1.5 to 2.5 g of mixed wood charcoal and carbonized nutshell or more than 2.5 g of pure wood charcoal. Grade C samples massed 0.5 to 1.5 g of mixed wood charcoal and carbonized nutshell or 1.5 to 2.5 g of pure wood charcoal. Grade D samples massed less than 0.5 g of carbonized material, and Grade F samples were those determined to be rodent-disturbed, from mixed proveniences or from otherwise suspicious contexts. Samples from twelve unit/level or feature contexts were selected for radiocarbon assay. Half of these were Grade A samples and were of sufficient mass to provide a radiocarbon assay without special treatment or extended counting time. The remaining samples were supplemented with carbonized plant remains extracted from the heavy and light fractions of associated flotation samples from the same provenience. Appropriate botanical analysis and documentation was performed on all samples selected for radiocarbon assay, after which the samples were sent as a group to Beta Analytic, Inc. The results of the radiocarbon assays were used to perform interunit stratigraphic correlations and to construct time-stratigraphic units (strata

sets) to be used in trend analyses of the major material classes. The results of the radiocarbon assays are discussed below in the appropriate section.

All recovered screen samples were transported to the Public Service Archaeology Program laboratory facilities at the University of Illinois at Urbana-Champaign where they were washed, labeled and inventoried. Inventory forms were used to tabulate preliminary counts and weights of major material classes (lithic, bone, shell, ceramic, plant remains, etc.) for each sample provenience (see Appendix C). Fire-cracked rock (Taggert 1981; Zurel 1979, 1982) was also segregated as a major material class. The most common material class by weight is lithic remains; the most abundant by count is bone. Ceramic artifacts, mussel shell, snail shell, and botanical remains were also recovered, though in fewer numbers than the lithic or bone artifacts. Lithic, ceramic, bone, shell, and botanical remains were subjected to more detailed analyses to extract information on the types of activities performed, subsistence practices, and paleoenvironmental conditions represented in each of the analytical units.

Flotation samples were collected in column fashion from excavation units whenever possible and from identifiable zones within designated cultural features. Sediment sample volumes were recorded in the field and later remeasured prior to processing in the flotation apparatus (Dausman Flote-Tech separator, Model A No. 6). The volumetric control of the processed samples is critical in establishing a degree of comparability for discreet categories of remains between divergent sample sizes. The light fraction was collected using a 0.4 mm woven cloth mesh; the heavy fraction was collected using a 1.0 mm mesh in the flotation chamber. Light and heavy flotation fractions were air-dried and bagged separately. The light fraction samples were sorted and prepared for analysis by separating the carbonized remains, bone, shell, and lithic artifacts from the mass of uncarbonized rootlets, small twigs, and other plant and inorganic debris that comprised the bulk of each sample. Heavy fractions were passed through nested 1-, ½- and ¼-inch screens, resulting in four size grades. Counts and weights of major material categories (lithic artifacts, ceramics, bone, mussel shell, snail shell, carbonized plant remains, fired sediment, and noncultural residue) were recorded for all size grades on inventory forms developed for the heavy fraction inventory.

After basic inventory of screened material, light fractions, and heavy fractions was completed, the separated material classes were distributed to various project personnel for detailed analysis. The primary author was responsible for description and analysis of the internal site stratigraphy (including major strata, minor substrata and associated cultural features), development of site chronology and dissemination of these data to the other analysts, and development of analytical units and correlated time-stratigraphic units. Ahler and Dr. Cynthia Balek collaborated on analysis of sediment samples that were taken from each major stratum and selected minor substrata. This analysis corroborates some of the stratigraphic trends observed during the excavation. Ahler also provides a general analysis of the major material classes, including examination of changes in density of material classes both horizontally and through time within the sampled deposits. This analysis provides a rough measure of changes in the intensity or frequency of human use of the site through time. These descriptions and interpretations of the site stratigraphy were in turn passed along to other project personnel to form a common analytical strategy. These topics are discussed first in the following sections, so that the reader may also share this common analytical foundation.

Other aspects of the analysis were divided among various analysts. Information on paleoenvironmental conditions that prevailed in the immediate vicinity of the site, and how these conditions changed through time has been extracted from analysis of terrestrial gastropod remains. These analyses were performed by Dr. James L. Theler of the University of Wisconsin—LaCrosse, and the results provide important information on the local effects of the Hypsithermal interval. Dr. Robert E. Warren of the Illinois State Museum analyzed mussel shell remains. These analyses provide additional paleoenvironmental data, and focus particularly on changes in the attributes of local fluvial conditions (stream flow, substrate composition, water depth, etc.).

Analyses of vertebrate faunal remains and archaeobotanical remains provide information both on paleoenvironmental conditions and on patterned cultural behavior that affected the amount and kinds of these materials that were incorporated into the Sadie's Cave deposits. Dr. Paul P. Kreisa of the University of Illinois analyzed the vertebrate faunal remains. His analyses discuss changes in assemblage composition and how these changes may reflect both changes in local species composition (paleoenvironmental conditions) and possible changes in subsistence patterns (cultural trends). Gregory R. Walz (University of Illinois) analyzed the archaeobotanical remains and discusses these same topics from the point of view of the preserved plant remains.

Later sections are devoted to analysis and interpretation of culturally derived material classes. Ahler analyzed the ceramic assemblage, the lithic debitage and the modified items (including both bone and lithic materials). These analyses provide information on the range of activities associated with specific occupational episodes. Ahler and Brian Adams conducted use-wear analyses on the modified items using both high-magnification and low-magnification analytical techniques. Together, these analyses provide more detailed information on the range of activities associated with each analytical unit and time-stratigraphic unit. Finally, Eve Anderson Hargrave analyzed the human skeletal remains recovered during these excavations; her report presents analysis of the Feature 2 skeleton and other human remains.

Specific techniques employed by the various analysts are discussed below in the respective sections that describe the various material classes and analytical topics. In general, the analyses incorporate materials derived from the 1993 test excavations into the discussion and interpretations. Only when the analytical procedures differed from year to year (as with the archaeobotanical remains) were the test excavation data excluded from consideration.

Following the results of the individual analyses, a section is devoted to discussion and integration of the results into a coherent interpretation of the site. This discussion focuses on extracting analytical trends that characterize the nature of the human occupations represented in the deposits, describe the paleoenvironmental conditions under which the human occupation occurred, and addressing possible interactions between the past environmental and cultural systems. These discussions utilize the analytical units and correlated time-stratigraphic units for comparison of lithic, ceramic, faunal, archaeobotanical, and paleoenvironmental data. This method of presentation facilitates examination of research questions dealing with diachronic change, and leads directly into an evaluation of the site-specific research goals and evaluation of the continuing research potential of the site.

Curation

All cultural material recovered during this project and all documents relating to the fieldwork and laboratory analysis of these materials were boxed for curation after completion of the analyses. All materials and records are the property of the U. S. Government. University of Illinois personnel have compiled lists of artifacts recovered and curation lists for the boxed materials and records. In addition, copies of all photographs, analysis forms and field forms pertaining to this investigation of Sadie's Cave are included in Appendix C. Qualified researchers interested in viewing the artifacts and documentation should contact USACERL. The human skeletal remains and associated grave goods are to be inventoried under an agreement with the U.S. Army Training and Doctrine Command (TRADOC) and the St. Louis District Corps of Engineers.

Stratigraphy

During the Phase II investigations (Ahler et al. 1995), information on internal site stratigraphy was revealed through two methods. First, backdirt was cleaned from the depression labeled Looter Pit #2, located near the south wall about five meters from the cave mouth. This activity exposed the curving north wall of what was interpreted then as a looter pit, which was sketched, photographed and used to guide subsequent stratigraphic excavation of the adjacent Test Unit 2. The second method of strata exposure was excavation of two test units (test units 1 and 2; see Figure 19) located in the central and eastern portions of the cave.

The stratigraphic sequences revealed in the two initial test units showed that the central portion of the cave (Test Unit 1)—with red-brown clay loam sediments exposed at the surface—contained virtually no cultural material except for scattered artifacts at or near the surface. In contrast, the eastern third of the cave—where dark brown and grayish-brown sediments were exposed on the surface—contained an intact sequence of stratified cultural deposits. Because of the differential distribution of intact cultural strata within the cave, the 1994 investigations were restricted to the eastern third of the cave. The following paragraphs document the stratigraphic sequences revealed in each isolated test unit or contiguous pair of test units. Both the 1993 and 1994 investigations are included to illustrate the stratigraphic contrast between the central and eastern portions of the cave.

As with the 1993 Phase II test excavations, each isolated test unit or contiguous set of test units has its own stratigraphic sequence. This results in five separate stratigraphic series (TU4/5 series, TU2/6 series, TU3 series, TU7 series, and TU1 series). No pedogenesis was observed in any of the strata. In each series, strata are numbered sequentially from top to bottom with arabic numerals used to designate major strata. Minor substrata, which are considered to be spatially discontinuous variations within a major stratum, are designated with a capital letter suffix added to the major stratum numeral (e.g.: strata 1A, 1G, 2B, etc.). The major and minor strata encountered in each test unit or pair of contiguous test units are described below. Table 5 presents formal descriptions of major strata encountered in each test unit. These descriptions are based on field observations; additional particle size data are presented later.

Test Unit 1

This unit was placed in the central portion of the site (Figure 17). Sediments indicating deposition by low-energy flowing water were observed at the surface in the south edge of the unit. This location was selected to provide data on the depositional history of the central part of the cave. The unit was excavated to 30 cm below ground surface in three arbitrary levels. Because of low artifact density, Level 4 consisted of an exploratory trench placed in the southern third of the unit to search for evidence of buried cultural strata. This trench was excavated to a depth of 66 cm below ground surface, and no intact cultural strata or features were found. The profile exposed by Test Unit 1 contains four strata (Figure 18a). All strata appear to be composed mainly of transported red clay and clay loam with varying amounts of angular to subrounded rock inclusions. The red clay probably represents a residuum of chemically and physically weathered dolomite that forms the rock matrix of the cave. Human additions to the sediment are very sparse. None of the Test Unit 1 strata are interpreted as culture-bearing deposits. Stratum 1 is a silty clay loam that overlies strata 2 and 3. Strata 2 and 3 are clay loams that differ only in the presence (Stratum 2) or absence (Stratum 3) of gravel-sized dolomite rock inclusions. Both strata 2 and 3 overlie Stratum 4, a darker red, rock-free clay loam.

Test Unit 2/6

Test Unit 2 was placed adjacent to what was interpreted as Looter Pit #2 and was oriented to semicardinal directions so that the southwest wall of the unit was formed by the exposed profile (Figures 17 and 19). The exposed profile of the looter pit showed artifact-bearing strata that were obviously different from strata exposed in Test Unit 1. After Test Unit 2 was excavated to expose culturally sterile residuum over the entire unit floor, Test Unit 6 was excavated immediately to the northeast, using the exposed profile to guide excavations. Because the same stratigraphic sequence is present in both test units, they are described together here. Figure 18b shows the northeast profile of the Test Unit 2 at the end of the 1993 test excavations. Figures 20–22 show the southeast profile (TU 2 and 6), northeast (TU 6 only), and northwest profile (TU 2 and 6) of contiguous units after completion of the 1994 excavations.

The TU2/6 strata are entirely different from those exposed in Test Unit 1, and no correlations are possible using elevation, or the physical or cultural attributes of the strata. Six major strata were defined for this test unit pair (Table 5). In addition to the major strata, several minor substrata variations were noted; these are discussed below in the text but are not included in Table 5.

Stratum 1 in general has a very high ash content and moderate amounts of charcoal and artifacts in a very dark brown loamy matrix. There are several minor subdivisions within this major stratum that may be related to individual occupation episodes, depositional events, or natural or cultural modifications of extant ground surfaces. Stratum 1A is a very friable gray ashy loam with weak angular structure and low to moderate gravel content. This stratum is separated from Stratum 1B by the Feature 1 ash lens and ashy surface; this separation is distinct only in portions of the northeast and northwest profiles (Figures 21 and 22); in other exposures strata 1A and 1B are not distinguishable. Stratum 1B, where it is distinct, is similar to Stratum 1A in most respects, but has slightly more charcoal and slightly less ash. Its lower boundary with Stratum 1C is smooth and clear. Stratum 1C is a friable gravelly loam with less ash and charcoal than strata 1A or 1B. Strata 1B and 1C become more similar to the northwest. The lower boundary with Stratum 2 is smooth

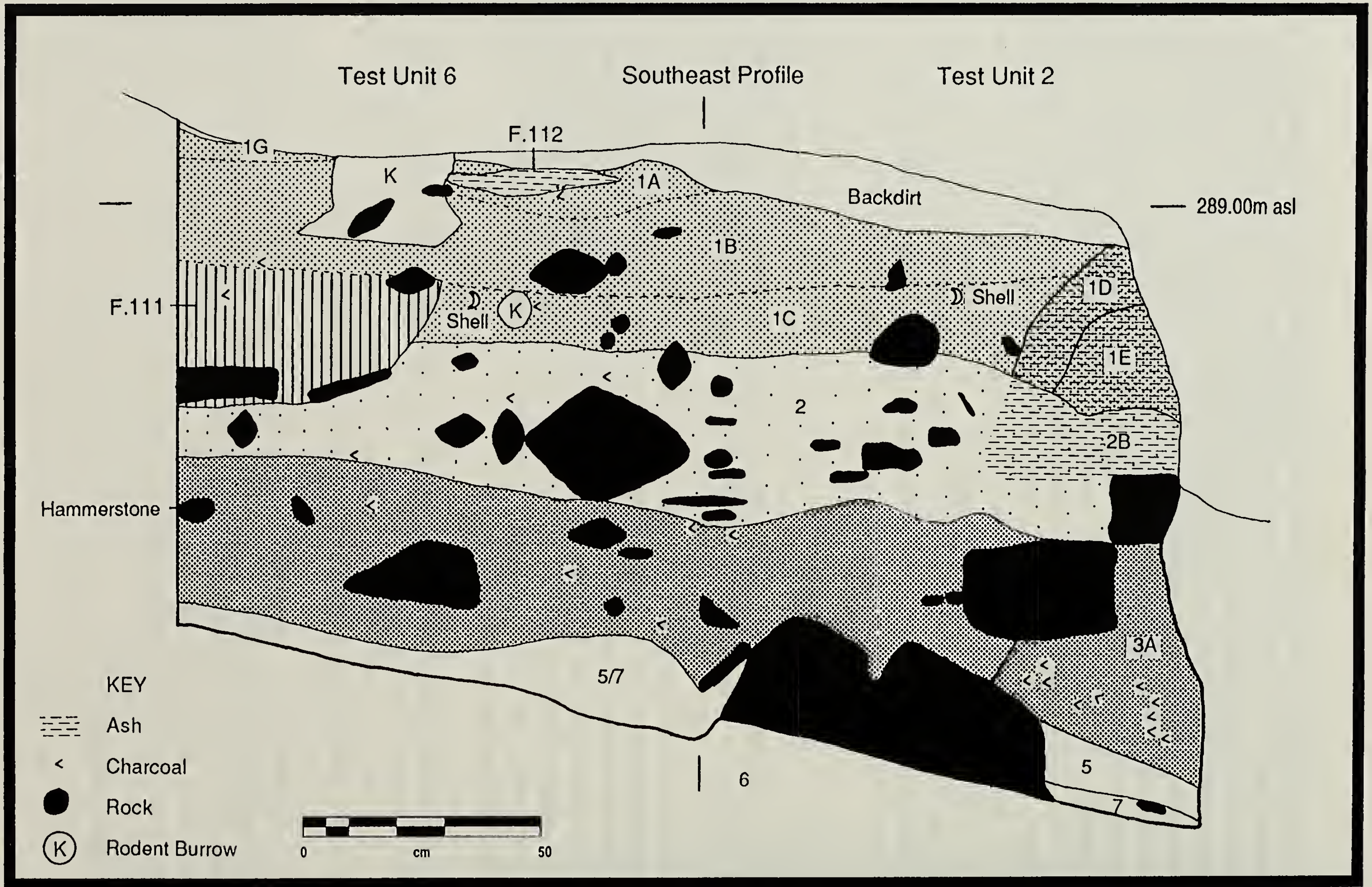


Figure 20. Sadie's Cave Test Unit 2/6 Southeast Profile.

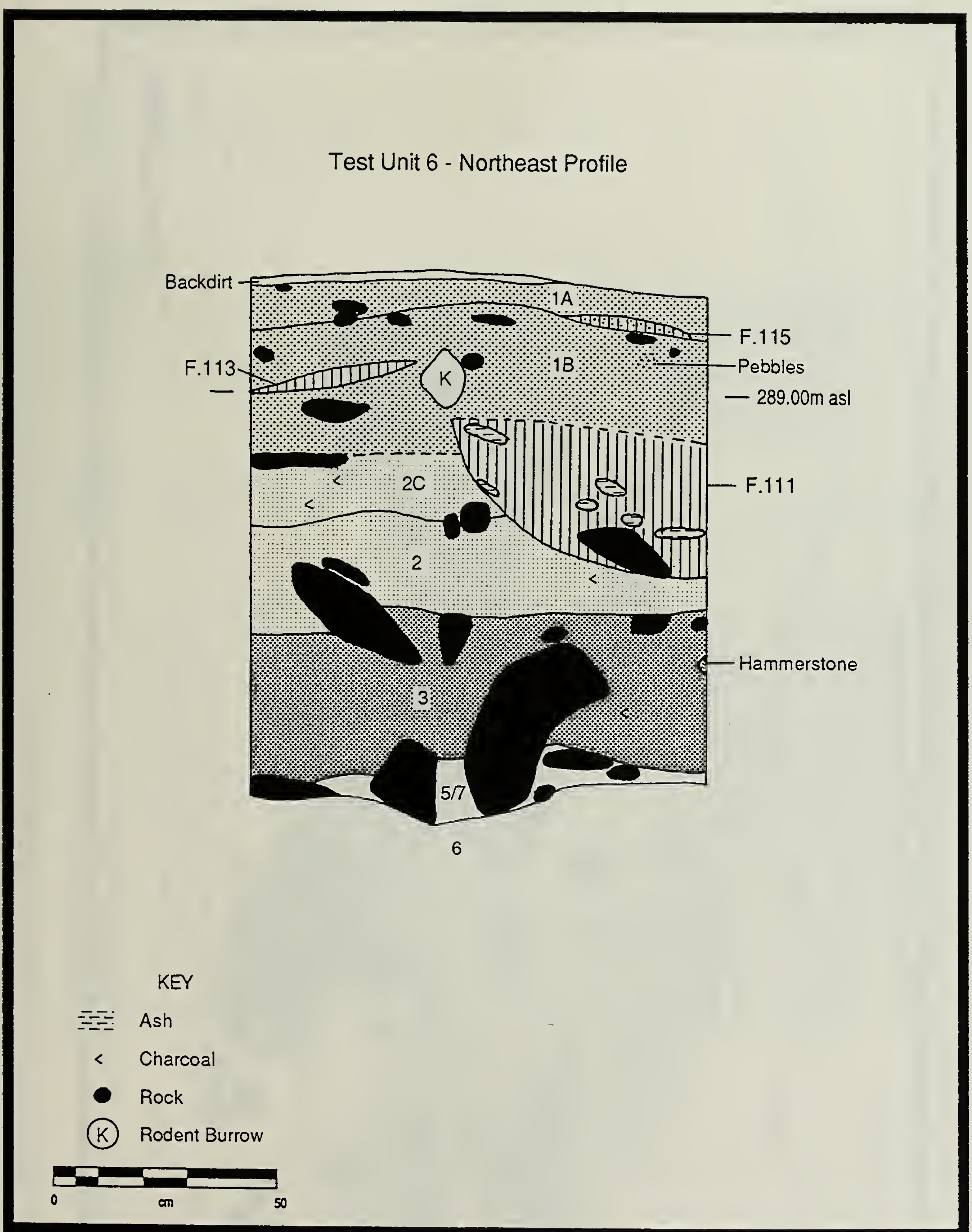


Figure 21. Sadie's Cave Test Unit 2/6 Northeast Profile.

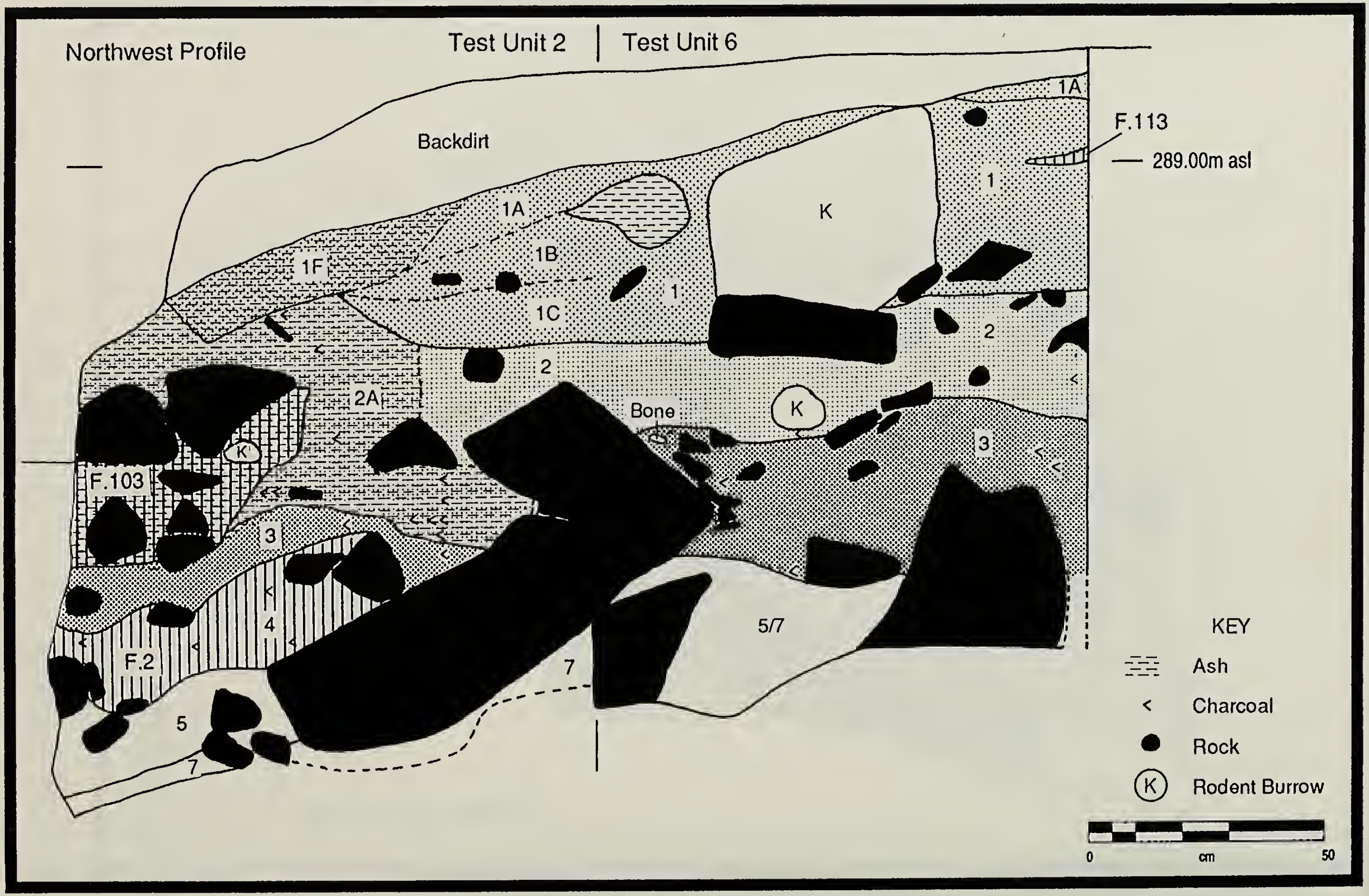


Figure 22. Sadie's Cave Test Unit 2/6 Northwest Profile.

Table 5. Field Descriptions for Major Strata in 1993 and 1994 Test Units at Sadie's Cave.

Stratum	Color	Structure and Texture	Cultural Material	Lower Boundary	Thickness Range (cm)
Test Unit 1					
1	10YR3/4 to 7.5YR4/6	Weak subangular blocky silty clay loam	Sparse	Clear, smooth	0–10
2	10YR3/6	Weak subangular blocky, gravelly silty clay loam to clay loam	Sparse	Clear, smooth	30–42
3	7.5YR4/6	Weak subangular blocky, rock-free clay loam	Sparse	Clear, smooth	32–33
4	7.5YR4/4	Weak subangular blocky, rock-free clay loam	Absent	Not observed	4+
Test Unit 2/6					
1	10YR3/1	Structureless ashy loam with common small rock and charcoal inclusions	Common	Clear, smooth	13–45
2	10YR3/4	Weak granular silt loam with common large rock and charcoal inclusions	Common	Clear, smooth	39–49
3	10YR4/4 to 10YR3/4	Weak subangular blocky, silty clay loam; large rocks common; charcoal decreases with depth	Common	Gradual, smooth	27–36
4	7.5YR3/4	Feature 2 fill. Structureless silty clay loam to sandy clay loam; localized chacoal concentrations	Present	Not observed	5+
5	10YR4/2 to 10YR4/4	Very weak platy to structureless, silty clay loam to clay loam; small-scale interfingered coarse sand to silt fining sequences present in lower parts; subrounded dolomite and chert gravels to cobbles common. Merges with Stratum 7 to northeast.	Sparse	Sloping, clear, smooth	6–20

Table 5. Continued.

Stratum	Color	Structure and Texture	Cultural Material	Lower Boundary	Thickness Range (cm)
Test Unit 2/6 (continued)					
7	7.5YR4/6	Reworked very weak platy to structureless, silty clay loam; subrounded dolomite and chert gravels to cobbles common	Absent	Sloping, abrupt, smooth	3–12
6	5YR3/4 to 5YR4/6	Basal Pleistocene-age residuum; angular to subangular blocky, silty clay loam to clay loam; both angular and subrounded dolomite and chert gravels-cobbles occasionally present	Absent	Not observed	12+
Test Unit 3					
1	10YR3/2 to 10YR3/3	Very weak fine subangular blocky, ashy loam with moderate gravel content	Common	Sloping, clear, smooth	13–30
2	10YR3/2 to 10YR3/4	Very weak fine subangular blocky, loam to silt loam; more gravel and cobbles and less ash than Stratum 1; clay increases to southwest	Common	Diffuse, smooth	17–23
3	10YR3/3	Very weak medium subangular blocky, silty clay loam; numerous gravel and cobble-sized angular rocks	Present	Clear, wavy	17–30
4	7.5YR4/6 to 10YR3/6	Reworked; very weak platy to structureless silty clay loam; low gravel content, but large gravel to cobble-sized subrounded rocks are common	Absent	Clear to abrupt, irregular	0–12
5	5YR4/6	Basal Pleistocene-age residuum; angular to subangular blocky, clay loam; angular dolomite and chert gravels-cobbles distributed irregularly within matrix	Absent	Not observed	0–6+

Table 5. Continued.

Stratum	Color	Structure and Texture	Cultural Material	Lower Boundary	Thickness Range (cm)
Test Unit 7					
1	10YR3/3 to 10YR4/3	Very weak granular, ashy loam to silt loam; several disrupted ash lenses present, but not identified as features; angular gravel common	Common	Clear, wavy	4–16
2	10YR3/4 to 10YR4/4	Very weak subangular, friable loam; less ash and more clay than Stratum 1; angular gravel and cobbles present; Stratum 2 not present in west corner of unit	Present smooth	Clear to abrupt,	0–12
3	10YR3/4 to 10YR4/4	Very weak subangular blocky, gravelly silty clay loam; numerous cobble-sized angular rocks; more compact that Stratum 2	Present	Clear, smooth to wavy	10–16
4	7.5YR4/4 to 7.5YR4/6	Reworked?; very weak subangular blocky to structureless gravelly silty clay loam; subrounded and angular gravels and cobbles present in erosional rills around large rocks	Sparse	Abrupt, smooth	4–9
5	7.5YR4/6	Reworked; very weak subangular blocky to structureless clay loam; subrounded gravel and cobbles common in erosional rills	Absent	Diffuse to clear, smooth to wavy	3–4
6	7.5YR4/6	Basal Pleistocene residuum; weak subangular blocky, clay loam to fine sandy clay loam; occasional angular gravels observed	Absent	Not observed	6+
Test Unit 4/5					
1	10YR3/2 to 10YR4/3	Very weak granular, friable, dry, loam; low ash and charcoal content; moderate gravel	Common to sparse	Clear, smooth to wavy	2–12
2	10YR3/2 to 10YR4/4	Very weak subangular blocky, loam; moderate gravel; ash content variable; thickens to SW	Present	Diffuse, smooth	14–57

Table 5. Concluded.

Stratum	Color	Structure and Texture	Cultural Material	Lower Boundary	Thickness Range (cm)
Test Unit 4/5 (continued)					
3	7.5YR4/4 to 10YR4/2	Weak subangular blocky gravelly loam; less friable than Stratum 2; grades into Stratum 5 to west	Common	4—Clear, smooth 5—Diffuse, irregular	22–30
4	10YR4/3	Feature 3 fill; weak subangular blocky loam; more compact than Stratum 3	Present	Not observed	0–5+
5	7.5YR4/4 to 10YR4/4	Very weak subangular blocky loam; moderate gravel; little charcoal or ash; not as firm as Stratum 3	Present	Clear to diffuse, wavy to irregular	18–42
3–5	10YR4/4	Similar to Stratum 5; gravel variable; strata 3 and 5 merge in west half of exposure; weak granular to structureless loam with little ash	Present	Sloping, diffuse, smooth to wavy	19–45
6	10YR4/3	Weak subangular blocky, firm loam with high ash content; localized cultural deposit?	Common	Abrupt, wavy	0–17
7	10YR3/4	Very weak subangular blocky, firm loam; more clay than Stratum 3/5, increasing some with depth; cobbles and boulders common; stratum thinner to S and W	Present	8—Clear, irregular 9—Abrupt, irregular	17–45
8	7.5YR4/4	Reworked?; weak subangular blocky silty clay loam; numerous gravel to boulder inclusions; very firm; stratum thickens to S and W	Sparse	Sloping, abrupt, wavy	5–42
9	5YR5/8	Basal Pleistocene residuum; weak subangular blocky, clay loam with occasional gravel to cobble inclusions	Absent	Not observed	0–12+

and diffuse and is formed in one section by an ash lens (Feature 104). At the southwestern end of both the northwest (Figure 22) and southeast (Figure 20) profiles, strata 1A, 1B and 1C become very ashy as a result of cultural additions of ash to the sediments. The high ash content may result from repeated refuse disposal in the low, basin-shaped depression that forms part of the natural drainage system within the cave. In the southeast profile, Stratum 1D is an unconsolidated ashy loam and Stratum 1E is a consolidated ash area below Stratum 1D. In the northwest profile, Stratum 1F is a correlate of Stratum 1D; no consolidated ash was observed in this profile. Finally, Stratum 1G is a localized lens of charcoal-rich ashy loam; it may represent a localized cultural activity or a lateral scatter of ash/charcoal related to the nearby ash lens of Feature 112.

Strata 2 and 3 have lower densities of artifacts, lower ash content and higher clay content in the sediment matrix, but texturally, they are still considered to be loams or sandy loams. Stratum 2 in general has more gravel- and cobble-sized rocks and less ash than the overlying Stratum 1 deposits. It also has lower densities of cultural material than Stratum 1. The stratum becomes more gravelly to the southwest in TU2, and in the northeast wall, there is a rock-free substratum (2C) at the boundary between major strata 1 and 2. Stratum 2 also becomes more ashy toward the southwest; strata 2A and 2B represent ashy substrata of Stratum 2 exposed in the northwest and southeast walls, respectively. Ash or refuse disposal in this portion of the cave may be a behavioral pattern with considerable antiquity. This observation suggests that a low drainage basin area existed in the cave throughout the time span represented by deposition of strata 1, 2 and 3. Partially removed by the looter pit/erosional depression is a large pit (Feature 103) which contains several cobbles and Stratum 2A sediments (Figure 22).

Stratum 3 is a loam to sandy loam that retains more moisture and is slightly more compact than overlying sediments. This stratum also contains numerous cobble- to boulder-sized rocks in addition to the gravelly soft sediment matrix. Stratum 3 overall has more scattered charcoal fragments than Stratum 2, and these fragments increase in frequency toward the southwest. These sediments become less compact, less gravelly and contain less clay in the northeastern exposure, where they are texturally classed as a sandy loam.

Stratum 4 was originally defined in the lowest portion of the 1993 test excavations. subsequent excavation revealed that Stratum 4 is actually the fill of Feature 2, a shallow pit containing the partially disarticulated remains of a single human burial. The feature fill appears to have a more loamy texture, is structureless and contains more charcoal and large rocks than overlying strata. Some of the large rocks were apparently intentionally placed over selected portions of the body (skull and upper torso), possibly to protect it from scavengers. Feature 2 is associated with the lower portion of Stratum 3, but there is no definite surface from which the feature originates.

Strata 5 and 7 are interpreted as Pleistocene-age sediments that have been reworked by local early Holocene colluvial or alluvial processes within the cave, resulting in admixture of a few artifacts, bones and charcoal fragments to what would ordinarily be culturally sterile red clay loam residuum. In this exposure, Stratum 5 is a silty clay loam to clay loam containing sparse amounts of artifacts. In the lower reaches of TU2, southeast of and below Feature 2, several thin fining-upward sequences of coarse sand, loam and silt loam deposits interfinger with more clayey loam deposits, indicating multiple short-duration depositional events that infilled the lowest reaches of the solution cavity drainage basin and passage prior to deposition of Stratum 3 and overlying sediments.

These events probably took place during the early Holocene. The underlying Stratum 7 contains little charcoal, ash or cultural material, but does include subrounded dolomite and chert gravels. The presence of subrounded rocks in the matrix suggests low-energy reworking of these sediments over a long period of time, probably during the late Pleistocene and early Holocene. Definite cultural additions to these reworked sediments are very rare, but bone fragments (possibly noncultural bone) are more common. Stratum 7 sediments fill two small erosional rills that have been cut into the underlying Pleistocene-age red clay loam sediments. In TU6, strata 5 and 7 are virtually indistinguishable and have been combined on the profile illustrations. The lower boundary of Stratum 5/7 is abrupt, smooth to wavy, and slopes to the southwest.

The basal Pleistocene sediments are represented by Stratum 6, a red-brown silty clay loam to clay loam with no cultural material included. The sediment matrix contains a mixture of both angular and subrounded cobble-sized rock, and gravel-sized rock is less frequent than in overlying Holocene cultural strata. No lower boundary was observed.

All major strata described in TU2/6 slope down toward the southwest, forming slopes that are roughly parallel to both the present ground surface and the late Pleistocene ground surface (top of Stratum 6). The Stratum 6 surface drops sharply down within TU2, and all overlying cultural strata also exhibit a greater slope near the southwest end of TU2. What was originally interpreted as a looter pit is now interpreted as a natural depression formed by occasional surface water runoff through the cave, which may have pooled for a short time before flowing out of the solution crevice at the cave wall south of the "Looter Pit #2" area. This solution crevice exits the bluff face about seven meters below and four meters southeast of the mouth of Sadie's Cave. That this solution crevice has been active throughout the Holocene is demonstrated by the consistently steeper slope of all major strata at the southwest end of Test Unit 2, partial removal of bones from the Feature 2 burial, and recovery of several bone, lithic and shell artifacts from the mouth and within the lower solution cavity passage.

Test Unit 3

Test Unit 3 was placed 1.5 to 2.5 m northwest of TU2, and was oriented so that the northeast profiles of both units lay along the same line (Figure 19). Excavation of this unit was in seven arbitrary and natural levels, and five strata were exposed (Figure 23).

Stratum 1 is a dark grayish brown ashy loam with moderate amounts of gravel and cultural material. It is similar overall to Stratum 1 in TU2/6 and includes several discontinuous localized ashy lenses and surfaces in the east corner, most of which were identified only in profile. No internal substrata were assigned in the field for the TU3 Stratum 1. Stratum 2 is a yellowish brown loam with locally heavy ash deposits and more clay than Stratum 1. Overall, this stratum has less ash and more gravel than Stratum 1. Stratum 3 is a yellowish brown silty clay loam with more large cobbles than either of the overlying strata. Strata 2 and 3 generally compare favorably to major strata 2 and 3 in TU2/6. Again, no internal substrata were defined for the TU3 strata. Stratum 4 is a clay loam with low sand and low gravel content. Numerous gravel-to-cobble-sized subrounded dolomite and chert rocks were observed. Based on these attributes, TU3 Stratum 4 appears to be very similar to TU2/6 strata 5 and 7 sediments; it is likely that TU3 Stratum 4 represents early Holocene reworking of the underlying Pleistocene red clay, with the addition of minor amounts of cultural material to the sediment matrix. The underlying Stratum 5 represents the culturally sterile

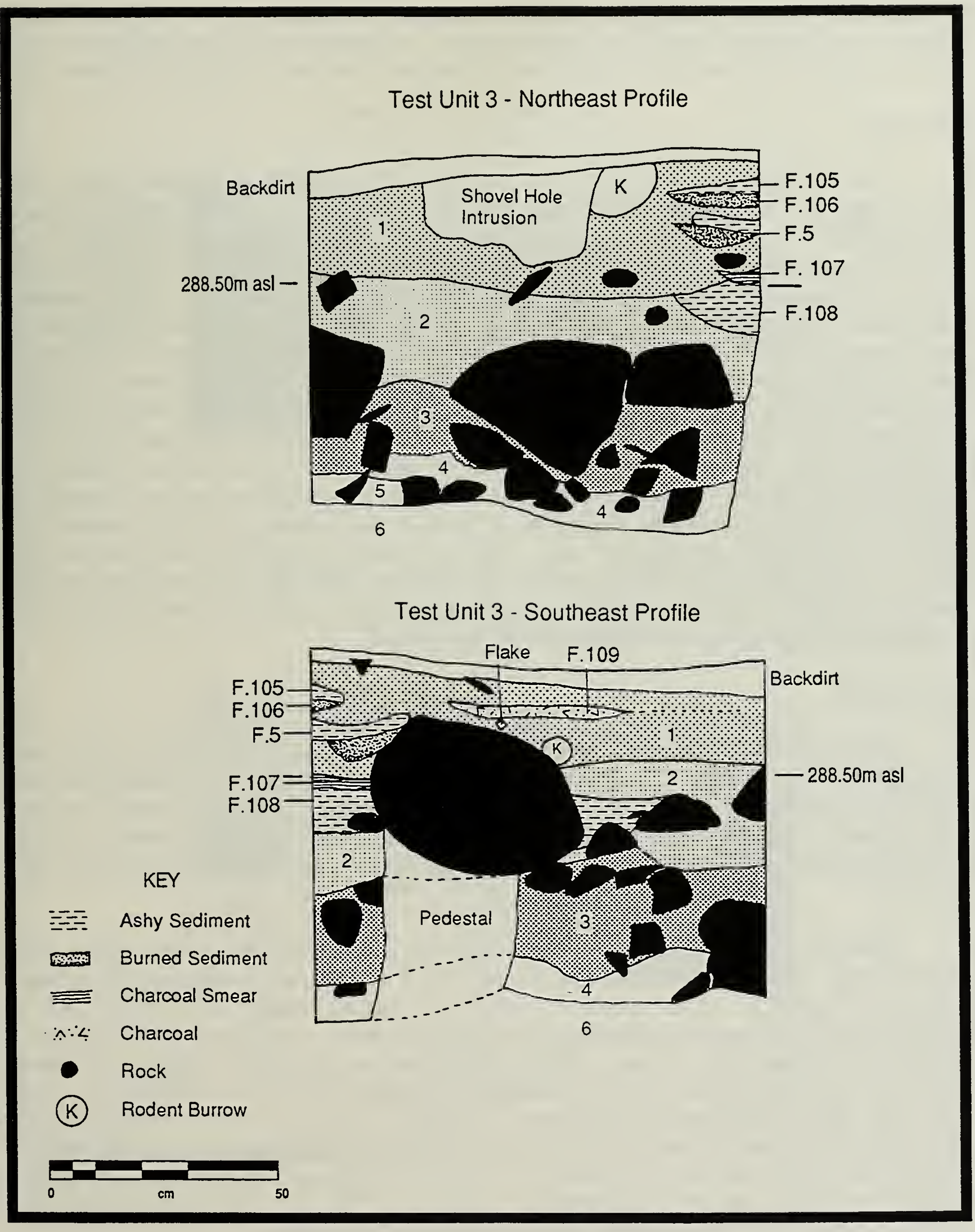


Figure 23. Sadie's Cave Test Unit 3 Profiles: a, Northeast Profile; b, Southeast Profile.

Pleistocene red clay loam residuum, and it contains angular gravel fragments irregularly distributed within the soft sediment matrix. The upper boundary of Stratum 5 forms an irregular surface that generally slopes down toward the south corner of the unit. No lower boundary was observed.

Test Unit 7

Test Unit 7 was placed 1.5 to 2.5 m northwest of TU3, and the northeast profile is aligned with the same wall of TU2 and TU3 (Figure 19). A series of six strata were defined for this test unit (Figure 24). The stratigraphic series in TU7 was very similar to that exposed in TU3. A dark grayish brown loam with common cultural material (Stratum 1) contained highly variable ash content. Several discontinuous surfaces were observed in profile, but none were given substratum designations. This ashy stratum overlies a firmer, yellowish brown loam (Stratum 2) which contains lower amounts of cultural material and higher clay and silt content. The Stratum 2/3 boundary is marked in places by a thin ash lens (Feature 110). Stratum 2 in turn overlies Stratum 3, a gravelly loam with numerous small angular dolomite and chert cobbles; this stratum is more compact and clayey than the overlying layers. Stratum 4 is a gravelly silty clay loam to clay loam with numerous subrounded rocks. Stratum 4 may represent localized redeposition of and cultural addition to the basal residuum sediments during the early Holocene. A Rice Lanceolate point was recovered at the Stratum 3/4 boundary, indicating deposition of strata 4 and 5 during the Early Archaic period. Stratum 5 is similar to Stratum 4, but contains little or no cultural material and numerous subrounded rocks. These rocks are particularly common in small erosional rills that have been cut into the underlying Stratum 6 sediments (Pleistocene-age red clay loam residuum) by surface water flowing downslope around the edges of two large dolomite boulders.

Test Unit 4/5

These units were placed just inside the cave mouth to maximize the depth of the cultural stratigraphic profile (Figure 19). The sediments in this part of the cave were much drier than in other areas, and the resulting profile showed several strata and substrata that were not observed in other exposures (Figures 25–27). Still, the overall stratigraphic sequence is similar to other test units, increasing the possibility of interunit stratigraphic correlations. Nine major strata were defined for TU4/5.

Stratum 1 is a coarse, gravelly gray to gray-brown loamy sand that is very friable to loose in consistency. It contains little charcoal, ash or cultural material, and these inclusions increase to the west. Stratum 1 overlies Stratum 2, which is a gravelly sandy loam with a little more compaction and more included cultural than observed in Stratum 1. To the west and south (generally in the TU5 exposure), this stratum is differentiated into upper (2A) and lower (2B) substrata. Stratum 2A is slightly lighter in color and contains less ash than 2B. The two substrata are separated by a very diffuse ashy/gravelly layer about 5 cm thick. This layer was not given feature or substratum designation because of its highly diffuse character. The lower boundary of Stratum 2B slopes down toward the west and south, resulting in levels that contain material from mixed stratigraphic contexts (TU4/L4 and TU5/L6). Strata 1, 2, 2A, and 2B are heavily disturbed by rodent burrows, some of which were excavated separately in the field.

Strata 2/2B overlies Stratum 3 in the north profile of TU4 and overlies Stratum 5 in the south wall of TU4. Strata 3 and 5 are very similar to each other. Both are friable gravelly sandy loams

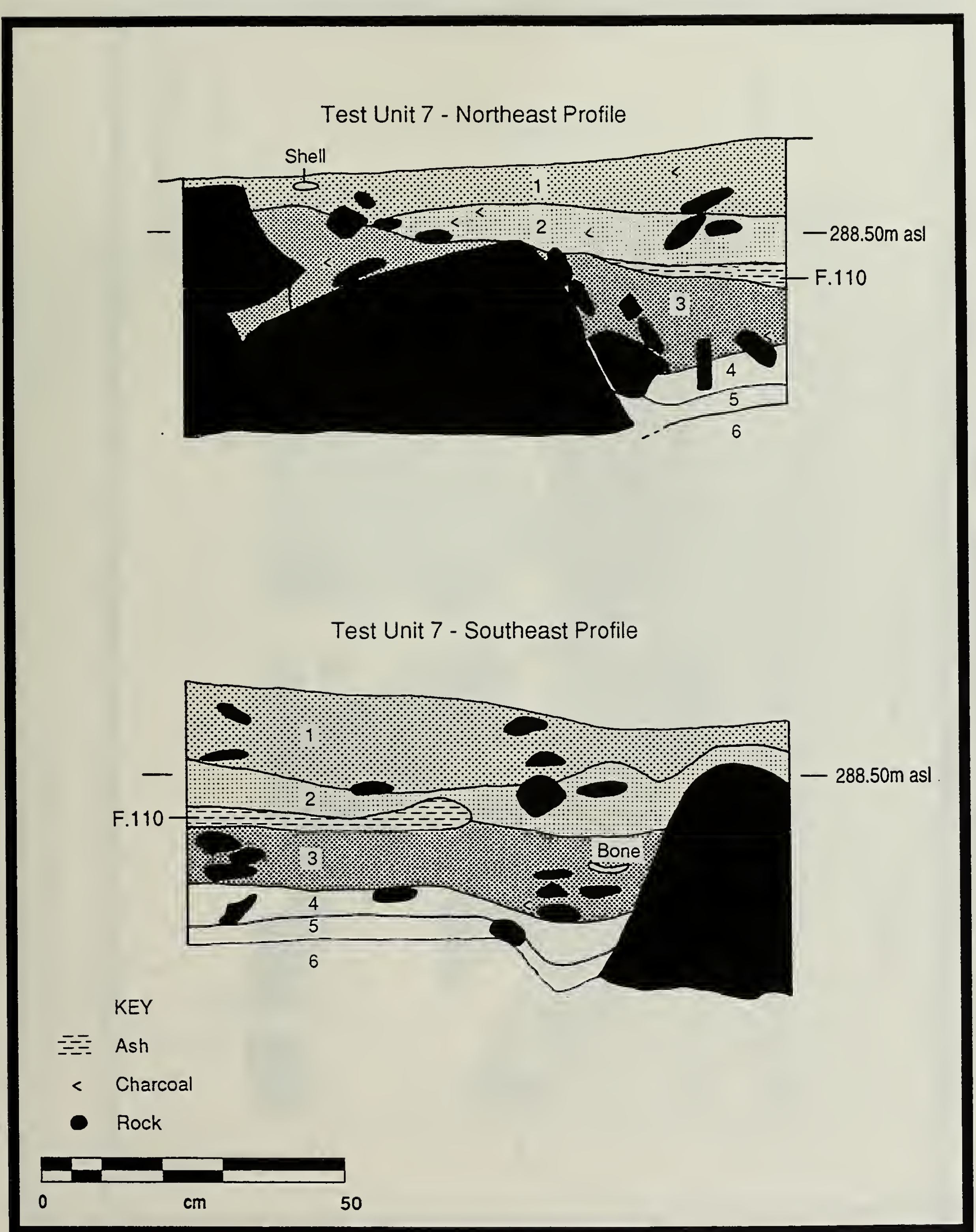


Figure 24. Sadie's Cave Test Unit 7 Profiles: a, Northeast Profile; b, Southeast Profile.

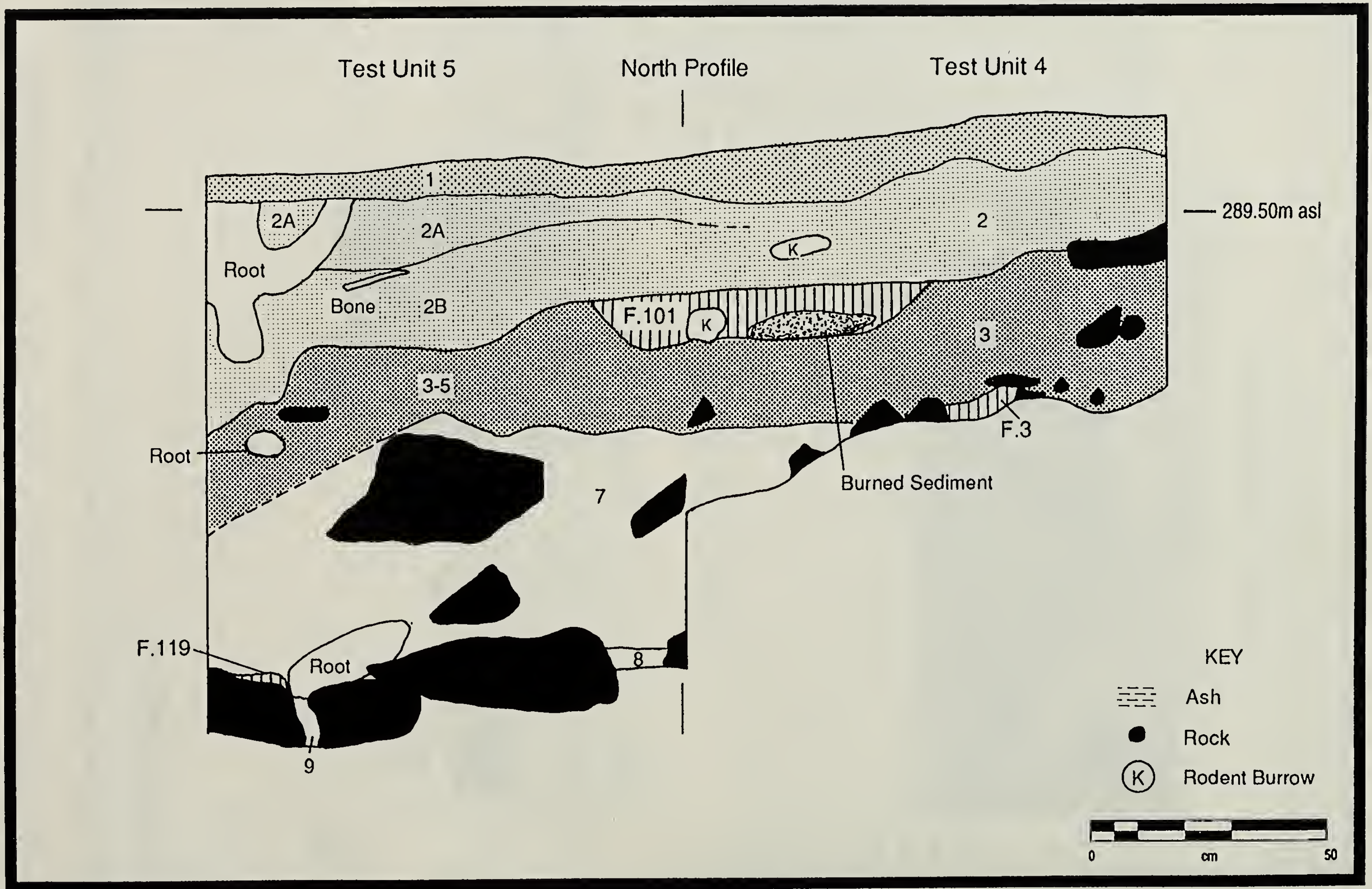


Figure 25. Sadie's Cave Test Unit 4/5 North Profile.

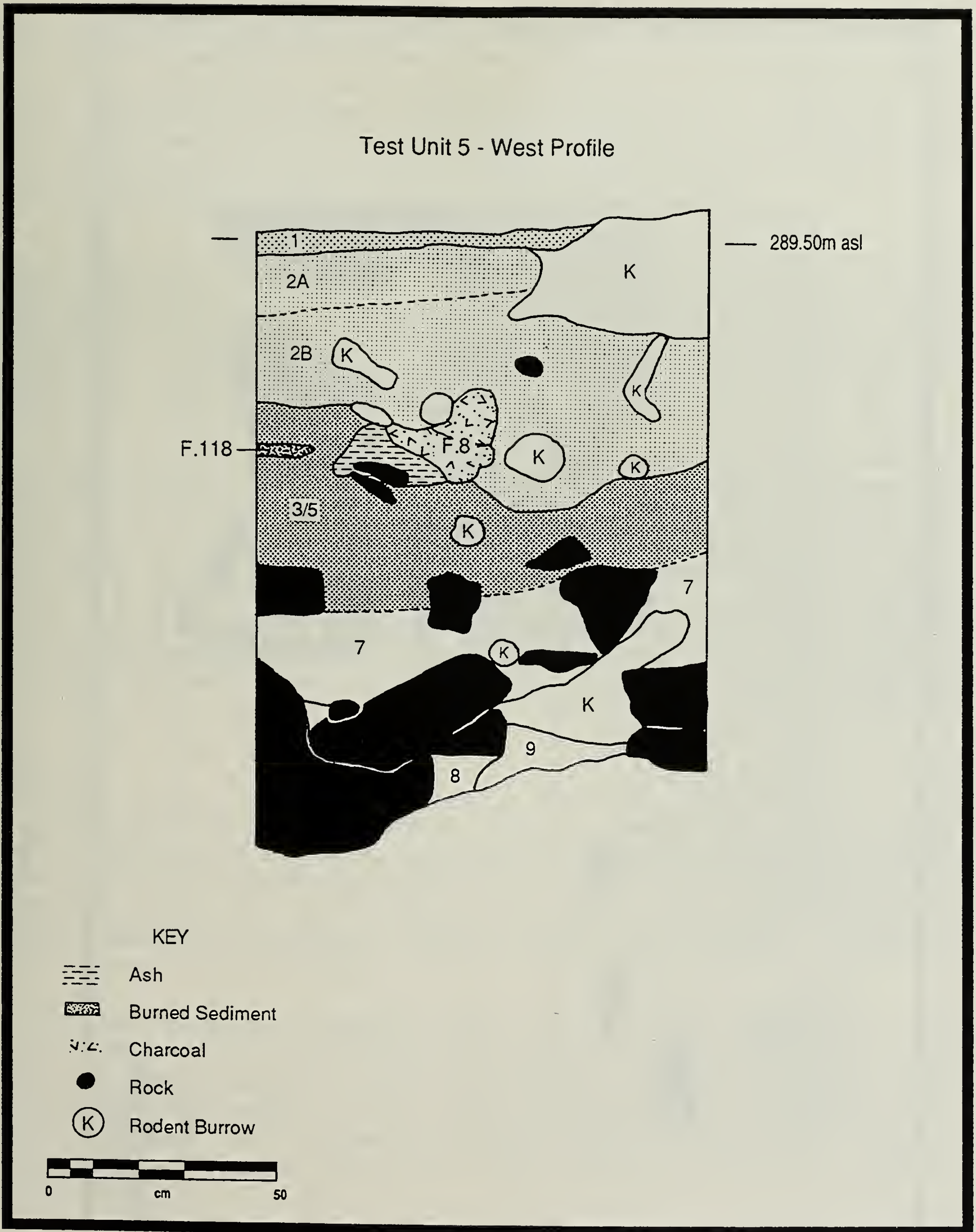


Figure 26. Sadie's Cave Test Unit 4/5 West Profile.

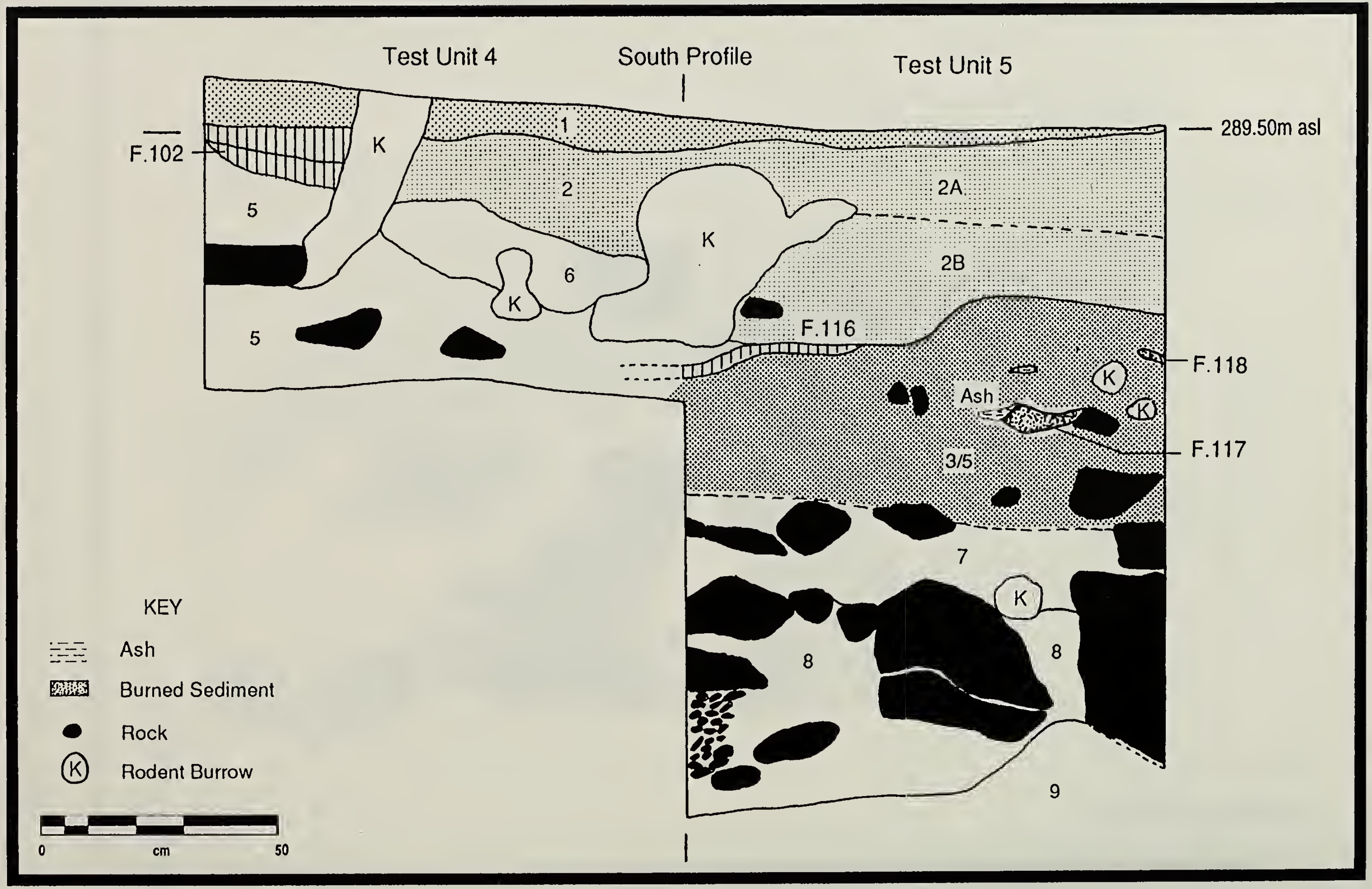


Figure 27. Sadie's Cave Test Unit 4/5 South Profile.

with low ash and charcoal inclusions. Stratum 3 is differentiated from Stratum 5 by higher gravel content and greater compaction in the former; the boundary between them is gradual and irregular, and is probably related more to local depositional events (creating more gravel and moisture in Stratum 3) than to cultural modifications. In TU5 and in the west wall of TU4, strata 3 and 5 could not be clearly differentiated; they are grouped as Stratum 3–5 in these exposures, in the excavation levels, and in associated analytical units. Stratum 3–5 slopes down sharply to the west, and one level (TU5/L11) represents mixed Stratum 3–5 and underlying Stratum 7 sediments.

Stratum 4 is the fill of Feature 3. It is similar in almost all respects to Stratum 3, but is more compact. It was exposed only minimally in the aborted TU4 excavations. Stratum 6 represents a localized deposit of loam that contains more ash and gravel than either Stratum 2 above or Stratum 5 below it. It is defined only in the south profile of TU4, and it may represent a localized deposit of ashy sediment derived from cultural activities. It was not sampled separately in the excavations, but portions of it are included in TU4 levels 3, 4 and 5.

Stratum 7 is a compact sandy loam to loam underlying Stratum 3–5; it seems to contain more cultural debris than overlying strata. In addition, cobble-sized rocks increase in frequency. It is underlain by Stratum 8 over most of the area of Test Unit 5, except in the extreme northern edge, where Stratum 9 is exposed. Stratum 8 is a reddish-brown, very compact loam containing little cultural material and large numbers of cobble-sized dolomite rocks. It forms a wedge of sediment that increases in thickness to the south and west in TU5. This stratum may represent early Holocene reworking of the basal Pleistocene red clay loam. The basal residuum sediment is labeled Stratum 9 in this test unit, and is similar to Stratum 6 exposed in Test Unit 2/6. However, like all overlying strata in the TU4/5 area, the basal residuum sediment is drier and is coarser in texture than correlated strata in other exposures.

Summary

The northeast profiles of the TU2-TU3-TU7-TU1 series form a southeast-to-northwest section through the western part of the Holocene sediments that accumulated in the cave. These profiles show that the thickness of cultural deposits decreases to the west. In addition, the major strata, though present in the same general sequence in all test unit exposures, generally become progressively thinner to the northwest. The ground surface drops in elevation and the basal Pleistocene residuum surface rises slightly in elevation from TU2/6 to TU1.

Test Unit 4/5 provides a stratigraphic column near the mouth of the cave, where it was expected that cultural deposits would be deepest. This exposures shows that the Pleistocene surface (top of Stratum 9) rises sharply between TU2/6 and TU4/5, resulting in Holocene cultural deposits that are about the same thickness in both areas. Sediments in the TU4/5 area are consistently drier than in other exposures, and artifact density was generally lower in this area compared to other test units. The differences in artifact density may be related to differential activity and disposal areas within the cave.

Except for the basal Pleistocene residuum, all strata within Sadie's Cave can be categorized as culture-bearing deposits. However, none of the strata represent a true midden or anthrogenic soil. Instead, artifacts derived from multiple occupation episodes accumulated within a slowly aggrading sediment matrix over long spans of time. Each individual episode of human occupation was probably

of short duration, but repeated use of the site over time resulted in accumulation of moderate amounts of lithic artifacts, bone, shell, and charcoal within the aggrading sediment cone at the eastern third of the cave. Similarly, there is no evidence for any rapid or catastrophic accumulation of sediments through noncultural depositional processes. Instead, all strata appear to have accumulated gradually over a fairly long period of time. Differences in the color, texture and inclusions within the strata may be due to a variety of factors, including the relative intensity of human occupation, spatially localized activity areas within the cave, proximity to sediment sources, amount of chemical weathering, or postdepositional alteration of sediments by erosional or depositional processes.

In spite of these potential sources of sediment differentiation, each test unit produced a series of strata that have similarities to the sequences in all other test units. This fact suggests that the strata can probably be linked across test units into larger, broadly contemporary strata sets that represent discrete time-stratigraphic units and broad periods of sediment aggradation and human use of the site. The effects of localized events, such as specific types of human activities recurring within the cave in localized areas or high-energy, short-term depositional events, appear to have had a minimal impact on the stratigraphic sequences within Sadie's Cave.

A generalized stratigraphic sequence for the eastern part of the site can be compiled from the common stratigraphic attributes presented in all test unit exposures. The uppermost stratum or series of strata is represented in all test units by dark, ashy, gravelly loams to sandy loams with apparently greater amounts of cultural material inclusions. These dark sediments are underlain by two major strata that are both loamy in texture but have higher clay content, less ash, less charcoal, less abundant cultural material, and increasing numbers of cobble-sized rocks, relative to the upper deposits. These strata are in turn underlain by a thin layer of clay loam to loam sediment that contains sparse amounts of cultural material. This zone forms a thin interface between the overlying cultural strata and the underlying noncultural basal residuum. There is evidence that these strata represent low-energy reworking of the basal residuum by a combination of human activities and surface water flow within the cave. These sediments probably were deposited and reworked during the early Holocene. Finally, the basal residuum deposits are represented by red clay to loam deposits that are devoid of cultural material. The residuum forms an irregular surface within the cave that slopes down toward the southern wall of the cave and the area of the solution crevice. Some erosional rills around large rocks have been subsequently filled with the reworked basal sediments.

The general slope of the residuum surface and presence of reworked sediments that are up to 30 cm thick in the southwest end of TU2 indicates that the solution crevice and associated processes of water-laid sediment deposition and episodic surface water ponding have been consistent attributes of Sadie's Cave throughout the Holocene. The morphology of the cave surface and the deposition of sediment within the cave have been affected and shaped by these drainage features and depositional processes for the entire history of its human occupation. Consequently, some refuse disposal activities may have revolved around the consistent presence of these internal cave features, resulting in repeated disposal of refuse in and around the natural drainage depression south of Test Unit 2.

The possible effects of the internal drainage pattern on refuse disposal activities can be further explored through analysis and detailed description of cultural features and their stratigraphic

relationships. In addition, detailed analysis of soil chemistry and particle size may also enhance our understanding of possible relationships among the test units and of the taphonomic processes that affected sedimentation within Sadie Cave. These discussions are presented in the following sections.

Cultural Features

A total of 28 features was identified during excavation and profile documentation. Both intrusive (pit) features and inclusive (surface) features are represented. For classificatory purposes only, the features have been divided into a series of morphological types within these two major feature classes. Inclusive feature types include ash lenses (Type 1A), surficial charcoal scatters (Type 1B), and fired sediment surfaces that may also have ash or charcoal associated (Type 1C). Most of the inclusive features do not have a definable stratum or substratum boundary as an associated surface. Instead, these localized concentrations are more often incorporated into the general accumulation of sediments within a given stratum. Intrusive morphological feature types include large, deep basin-shaped pits (Type 2A), small, shallow basin-shaped pits (Type 2B), and burials (Type 3). Type 1A is the most common feature type, and it is represented at least once in each test unit or test unit pair, except for Test Unit 1.

Features were given numbers in two series. Low numbered features (1–9) were recognized during the course of excavation and consequently have at least flotation or carbon samples extracted from them. High-numbered features (F101–119) were recognized as features in profile after they had been excavated As a consequence, these features may not have any samples (carbon, screen or flotation) extracted directly from them. Their contents may only be included in the natural or arbitrary levels with which they are associated.

Table 6 provides a brief description of each feature numbered in the field and lists the morphological feature type, maximum dimensions, associated unit and stratum, the profile and figure in which it is illustrated (if any), and the samples extracted (if any). In addition to the features described here, several discontinuous ashy surfaces were noted during excavation of TU7/Stratum 1. These were convoluted and broken surfaces which were probably damaged by surface water runoff at the western footslope of the sediment cone accumulation. Because these surfaces were discontinuous, fragmented, and possibly damaged by erosion, none of them were assigned feature numbers. Selected features are described in detail in the following paragraphs.

Of the 20 surface features (Types 1A, 1B and 1C), 12 were associated with the uppermost dark, ashy stratum found in each test unit (Stratum 1 deposits in test units 2/6, 3 and 7; Strata 1/2A/2B deposits in TU4/5). Four of the six nonburial pit features (Type 2A and 2B) were associated with the same set of upper strata. This higher frequency in the upper deposits may be due either to better preservation in the more recently deposited upper stratum or to an actual increase in the frequency or duration of occupation during deposition of these upper strata. Higher frequencies of both intrusive and inclusive features and observations of greater artifact density/frequency in the upper stratum of each test unit (see Table 5) support the interpretation of more intensive or frequent use of the site during deposition of these strata.

However, almost all strata, except for the potentially reworked early Holocene deposits near the base of each test unit, contain evidence of either inclusive or intrusive features. This finding

Table 6. Descriptions of Sadie's Cave Features, Arranged by Test Unit.

Feature Number	Feature Type	Description	Maximum Dimensions (cm) Length	Width	Depth	Stratum	Profile	Figure	Samples	Comments
Test Unit 2/6										
1	1A	Ash lens/surface	110	54	4	1A	TU2 NE	None	F,C,S	F114 may be part of F1
2	3	Burial	118	88	25	3	F2	20, 29	F,C,H,S	Detailed description in text
103	2A	Rock-filled pit	?	48+	43	2	TU2 NW	22	None	Ashy and rocky fill
104	1A	Diffuse ash lens	56+	53	5	2	TU2 NE	None	F	
111	2A	Ash-filled pit	56+	55+	30	1B	TU6 NE,SE	20, 21	None	Ashy fill not distinguished during excavation; see text
112	1A	Ash lens	37	?	6	1G/1A	TU6 SE	20	F	
113	1A	Ash lens	35+	13+	4	1B	TU6 NE TU6 NW	21 22	None	Included in TU6 levels 2–3
114	1A	Consolidated ash	20+	?	16	1	TU6 NW	22	None	May be part of F1
115	1A	Ash/charcoal lens	27	?	3	1G/1B	TU6 NE	21	None	Included in TU6 Level 1
Test Unit 3										
4	2B	Ash-filled basin	38	27	8	1	None	None	F	Detailed description in text
5	1C	Ash lens and fired sediment surface	60+	33+	8	2	TU3 NE,SE	23	F	
105	1A	Ash lens	20+	8+	3	1	TU3 NE,SE	23	None	Associated with F106 fired sediment surface
106	1C	Fired sediment	20+	8+	3	1	TU3 NE,SE	23	None	Associated with F105 ash lens
107	1B	Charcoal scatter	13+	9+	3	2	TU3 NE,SE	23	None	Associated with F108 ash lens
108	1A	Thick ash lens	78+	18+	10	2	TU3 NE,SE	23	None	Included in Level 3; associated with F107 charcoal scatter
109	1B	Charcoal scatter	38	?	3	1	TU3 SE	23b	C	Carbon taken from profile
Test Unit 7										
110	1A	Ash lens	47+	30+	5	2/3	TU7 NE,SE	24	None	Included in Level 3

Table 6. Concluded.

Feature Number	Feature Type	Description	Maximum Dimensions (cm) Length	Width	Depth	Stratum	Profile	Figure	Samples	Comments
Test Unit 4/5										
3	3	Burial	70+	65+	5+	3	TU4 N	25	F,C,H,S	Detailed description in text
6	1C	Ash/fired surface	60	47	9	2A/2B	None	None	F,S	Detailed description in text
7	1A	Ash lens	61	30	7	2B	None	None	F	May be associated with F8
8	2B	Charcoal-filled basin	35+	25	21	2B	TU5 W	26	F,C	Detailed description in text
9	2B	Shallow basin?	65	35+	7	3–5	None	None	F,C,S	Ashy/fired sediment fill
101	2B	Ash-filled basin?	70+	52+	12	2B	TU4/5 N TU4 W	25 None	F,C,S	Detailed description in text
102	1C	Ash/fired surface	31+	?	12	2	TU4 S	27	None	Included in TU4, levels 2–3
116	1A	Diffuse ash lens	37+	?	3	2B/3–5	TU5 S	27	None	Included in TU5, Level 6
117	1C	Ash/fired surface	22	?	6	3–5	TU5 S	27	None	Included in TU5, Level 9
118	1C	Fired surface	12+	5+	3	3–5	TU5 W,S	26, 27	None	Included in TU5, Level 7
119	1C	Ash/charcoal/fired surface	75+	52+	5	7/8	TU5 N	25	F	Very diffuse area, may be rodent-disturbed

Note: Samples are coded as flotation (F), carbon (C), human bone (H), and screened material (S) sample types that were extracted specifically from the designated feature. A + for any dimension indicates that the given measurement represents a minimum distance observed because of damage by excavation or erosion.

indicates that human activities contributed to and altered in some way the aggrading cave sediments during all major occupation periods represented at Sadie's Cave. All of the occupations may have been largely episodic and of generally short duration, but either individually or collectively, they were of sufficient intensity to result in accumulation of cultural debris in the sediment matrix and to modify the ground surface through excavation of pit features and construction of heating/cooking facilities (surface features). At least one fired surface and diffuse ash/charcoal scatter was observed at the top of the reworked basal residuum sediments (F119, TU5), indicating human occupation and alteration of the cave deposits during the earliest period of Holocene sediment reworking and accumulation. When more loamy Holocene sediment later began to accumulate within the cave due to formation and lateral spread of a colluvial sediment cone on the bluff face ledge outside of the cave mouth, evidence for short-term episodic use of the site was much more likely to be preserved in the form of surface features sealed within the aggrading sediment matrix.

Stratum 1 deposits in TU3 and TU2/6 exhibit a series of superimposed ash lenses, some of which are associated with underlying fired surfaces. In TU2/6, Feature 1 may be associated with Feature 114, a consolidated ash concentration lateral to and at about the same elevation as Feature 1. Features 104, 112, 113, and 115 form additional surfaces/ash lenses that are partially superimposed within TU2/6 Stratum 1 (see Figures 20–22). In TU3, there are three features or associated feature sets (ash lenses with underlying fired surfaces) that are superimposed within Stratum 1 and the uppermost portion of Stratum 2 (see Figure 23). The uppermost of this series is composed of the F105/106 pair and a possible lateral charcoal scatter (Feature 109). These are separated from the underlying Feature 5 (containing an ash layer over a fired surface) by an unfired portion of Stratum 1 sediments. Feature 5 in turn overlies the F107/F108 charcoal lens and underlying thick ash deposits at the Stratum 1/2 boundary. The presence of several sets of superimposed surface features suggests that during accumulation of Stratum 1 deposits, specific portions of the cave interior were repeatedly used for similar types of activities. This finding suggests that there was repeated, structured use of the cave during this time span for a particular set of purposes, and that all or most of the individual occupation episodes contained within the uppermost stratum may be functionally or temporally related.

One interesting aspect of the features at Sadie's Cave is that at least two of the shallow basins seem to be associated with laterally adjacent fired surfaces. In TU4/5, Feature 8 (Figure 26) is a shallow basin filled with carbonized bark and wood charcoal; it is about 25 cm west of Feature 7 (not illustrated), which is a thin ash lens with small amounts of included charcoal and fired sediment. In TU3, Feature 4 is a shallow ash-filled basin, and it is immediately adjacent to the F105/F106 complex (ash lens and underlying fired surface) and about 20 cm west of the F109 charcoal scatter. It is possible that the shallow basins in these feature complexes represent shallow earth ovens or roasting facilities and that the adjacent fired surfaces and ash/charcoal scatters represent either functionally related surface fires or debris scatters resulting from cleaning the shallow basins. Similar paired feature sets have been observed in Archaic period stratigraphic contexts at Modoc Rock Shelter in southwestern Illinois (Ahler 1986a; Ahler et al. 1992). It is possible that functionally similar sets of features were used throughout the prehistoric era, and that these features at Sadie's Cave also represent functionally related sets of heating, roasting and cleaning activities.

Other shallow basins with ashy fill (Features 9 and 101) may represent a different set of functional features. There are no surface scatters of ash or charcoal and no fired surfaces immediately adjacent to these basins, though in the case of Feature 101, at least half of the feature

remains in the unexcavated north profile. These features may represent hearths or cooking facilities that were not functionally related to nearby surface features.

Two deep Type 2A pit features (Features 103 and 111) were defined in profile after excavation; neither of these produced samples from unmixed feature contexts (see Figures 21 and 22). Both of these pit features contain ashy fill and several large rocks. In Feature 111, the ash is partially consolidated into several large aggregates within the pit feature; the ash in Feature 103 was not consolidated. Neither the pit morphology nor feature fill characteristics provided many clues to the function of these facilities. Both contained ash but there was no evidence of in situ burning; the ash may represent a secondary deposit within the feature and not be indicative of the primary feature function. The fact that the fill was very similar to the surrounding sediment matrix indicates that they were not used for refuse disposal. The function of these larger pit features remains unknown at this time.

Of importance to site function interpretations was documentation of two primary human burials (Features 2 and 3) in different strata within Sadie's Cave. These features and their context will be described in detail.

Feature 3

This feature was encountered at the bottom of Level 6 in Test Unit 4 (Figure 25), when articulated right femur/patella/tibia and distal right arm/hand segments were exposed. A few small human bone fragments had been noted during excavation of Level 6, but these had not been articulated with other elements. Upon exposure of the articulated elements, careful troweling of the floor revealed a very tenuous feature outline (Figure 28) in the northeast quadrant of the unit. Several large rocks were included within the possible feature boundaries, especially at the east edge of the test unit. Examination of the north wall profile (Figure 25) showed that Stratum 4 was more compact than the overlying Stratum 3 matrix, but was otherwise very similar. Stratum 4 is tentatively interpreted as the Feature 3 fill. The burial is most probably associated with the lower portion of Stratum 3–5.

In accordance with a previous agreement with the Legacy Program administrator (Marie Cottrell) and with the project Statement of Work, once articulated human skeletal remains were encountered, our efforts then became focused on determining the orientation, age, sex, and state of preservation of the individual while inflicting minimal disturbance to the burial. Level 7 of TU4 was excavated with the goals of 1) determining a grave pit outline; 2) exposing enough of the bones to determine orientation of the elements and general location of the remaining major body portions so that further excavation could continue and the articulated burial could be avoided; and 3) exposing enough of the bones to determine age, sex, pathologies, and state of preservation of the individual without actual removal of the bones from their intact sediment context. Excavation of Level 7 was halted when these objectives were reached. The feature was then drawn, photographed, and described. In-field analysis of the exposed skeletal elements was facilitated by the use of Bass (1971) as an identification manual.

The Feature 3 burial consists of a single articulated individual of adult age that has been partially disturbed by rodent burrows and by our limited excavations. All bones were in very good to excellent state of preservation. Preservation has been enhanced by the local conditions within

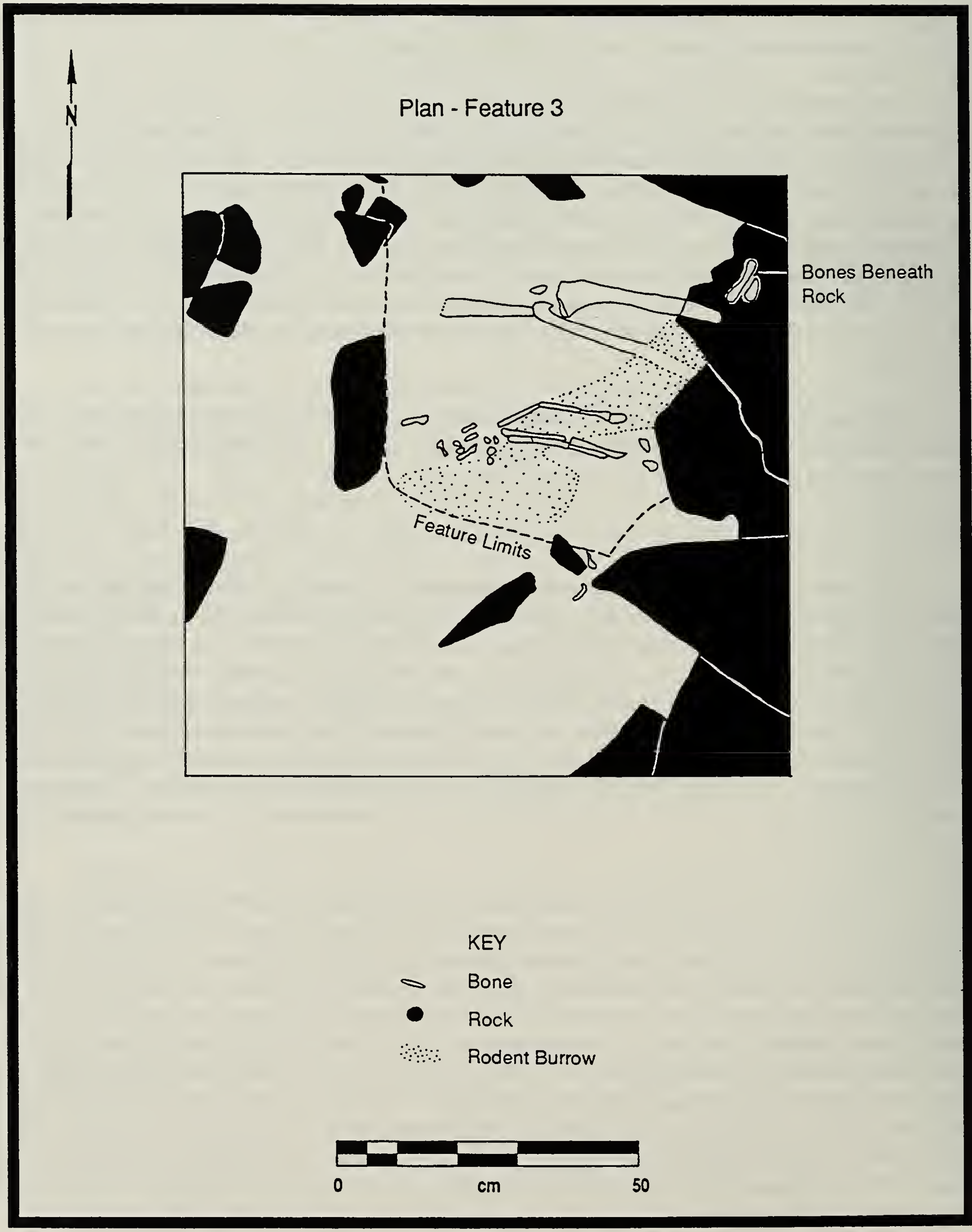


Figure 28. Sadie's Cave Feature 3 Burial (TU4/Level 7).

Sadie's Cave, which include high soil pH and relatively dry conditions near the cave mouth. Several of the bones had been broken after deposition, and three of them appear to have been gnawed by small rodents. A rodent burrow has partially disturbed the central part of the burial area (Figure 28), but it has not caused major displacement of skeletal elements.

The individual is lying on his/her left side with both legs in a flexed to semiflexed position; the right femur and tibia are almost parallel to each other (Figure 28). The right arm is extended parallel to the right femur and the bones of the right hand are partially disarticulated and scattered through bioturbation. The right ulna and radius are broken in several places. Along the east wall of Test Unit 4 and partially covering the Feature 3 burial are several large boulder-sized rocks. Disarticulated vertebra and rib fragments were found near the base of these large rocks. These rocks do not appear to rest on top of the bones, but several may have been placed over the body at the time of death to protect the body from scavengers. The very shallow nature of the Feature 3 grave (Stratum 4) and its greater compaction relative to overlying sediments support this interpretation. The rocks may have functioned as a small burial cairn, similar to the larger bluff crest cairns commonly observed in the Ozark region.

Age of the individual could not be determined definitively, but the person was a full adult at the time of his/her death. All epiphyseal sutures are fully closed. No elements, such as teeth, skull or pelvis, were exposed that could provide a more accurate determination of age of the individual at death. Likewise, the sex of the individual could not be determined from the limited array of exposed skeletal elements. The skull is probably located underneath large rocks near the southeastern corner of the unit, while the pelvis is probably under other large rocks in the northeast corner or east wall of the unit. The elements exposed during excavation of levels 6 and 7 were examined in situ for evidence of bone pathologies, but none was found.

After documenting the location and condition of the remains, the decision was made to abandon further excavation of Test Unit 4. Instead, excavations commenced in the 1-x-1-m unit immediately adjacent to the west and farthest away from the burial (Test Unit 5). By following this course of action, the intact human remains in TU4 were avoided, and the exposed west wall of TU4 was used to guide the stratigraphic excavation of TU5. The burial was documented as thoroughly as possible under these circumstances of partial exposure and excavation. All human skeletal elements that were known to have been associated with the burial (removed during excavation of Level 6 or displaced during exposure of bones) were identified as to element using Bass (1971) as a reference. These bones were placed inside a plastic ziplock bag along with a list of the identified skeletal elements (see section on Human Skeletal Remains for the list of identified elements) and a paper tag documenting the date of excavation and institutional affiliation of the excavator. The bag was placed between the exposed right femur and right ulna of Feature 3 and the entire feature was covered with plastic sheeting. Then the unit was partially backfilled to cover the bones and grave outline and to provide a buffer so that we could continue our excavation activities in the adjacent Test Unit 5 without fear of destroying the human remains or further disturbing the burial context.

Feature 2

Initial Encounter (1993). This feature is a partially articulated human burial associated with the lower portion of TU2 Stratum 3 sediments (Figure 22). A few disarticulated skeletal elements were recovered from TU2 Level 9, and articulated remains were exposed at the bottom of TU2 Level

10. Feature 2 was initially encountered during the 1993 Phase II test excavations, and when the articulated right tibia/fibula/femur were exposed in the bottom of Level 10, excavation was halted to avoid unnecessary disturbance of an intact human burial. Disarticulated elements had been encountered in levels 9 and 10, and it was surmised at the time that the burial had been partially disturbed by either erosion or scavengers' actions. When excavations resumed in 1994, we knew that a burial was present in the TU 2, but we did not know much about the context, orientation, or extent of disarticulation of the remains. In addition, the 1993 test excavations had provided material that had been radiocarbon assayed. A single large fragment of carbonized wood charcoal was removed from fill adjacent to the right tibia. Two AMS determinations obtained on split fractions of this sample both assayed to 7780$\pm$70 B.P. These assays indicated that the burial was interred during the early part of the Middle Archaic period.

Kristin Hedman of the University of Illinois examined the skeletal elements removed during Phase II testing for possible determination of age, sex and pathologies. None of the recovered elements (proximal right tibia and fibula, distal right femur, and disarticulated cervical vertebra and clavicle fragments) exhibited attributes that indicated the sex of the individual. The proximal epiphysis of the tibia is only recently fused, indicating an age at death of 20$\pm$5 years (Bass 1971:184). No bone pathologies were observed.

Removal Procedure (1994). In 1994, the southeast half of the TU2 sediments were removed from levels 6 through 10 to bring the excavations to the same elevation in both halves of the test unit. We maintained a careful watch for any differences in sediment that would indicate the presence of pit fill or identify the grave outline, but no differences were noted until Level 10 was fully exposed. At that level, several large rocks were present on the unit floor, which further obscured identification of the grave outline. The ends of the femur, tibia and fibula elements that were left in place at the end of the 1993 testing were relocated, and a small amount of sediment was removed to confirm the orientation of these elements. Based on this limited information, it was interpreted that the burial was likely positioned on his/her left side with the pelvis near the west-central part of the unit. Accordingly, additional sediments were removed from the southeast half of the unit as Level 11; it was thought that this action would effectively avoid the burial. A flotation sample was taken from the east corner of the unit without encountering human remains. When excavations were expanded to the south and one of the large rocks in the floor was removed, portions of the pelvis were exposed.

Based on this new information, it was apparent that the burial was nearly centered in Test Unit 2, and that very little of the test unit could be excavated without further impacting the grave. After consultation with the Fort Leonard Wood Cultural Resource Manager and the Legacy Program administrator, it was decided that excavation of the burial was warranted in order to reach the overall project goals. Once this decision was made, the burial was completely exposed and the excavation/removal process was fully documented through a series of intermediate and final plan drawings and photographs. The following paragraphs describe and interpret this burial feature.

Grave Description. The grave outline was very difficult to determine, and the limits of the feature noted in Figure 29 were determined by the slightly less compact sediment within the proposed feature area and relatively greater abundance of charcoal within the grave fill. The grave fill is very similar to the surrounding Stratum 3 matrix. If the grave outline depicted in Figure 29 is correct, the feature was most likely a large shallow basin excavated between two large rock-fall blocks. The

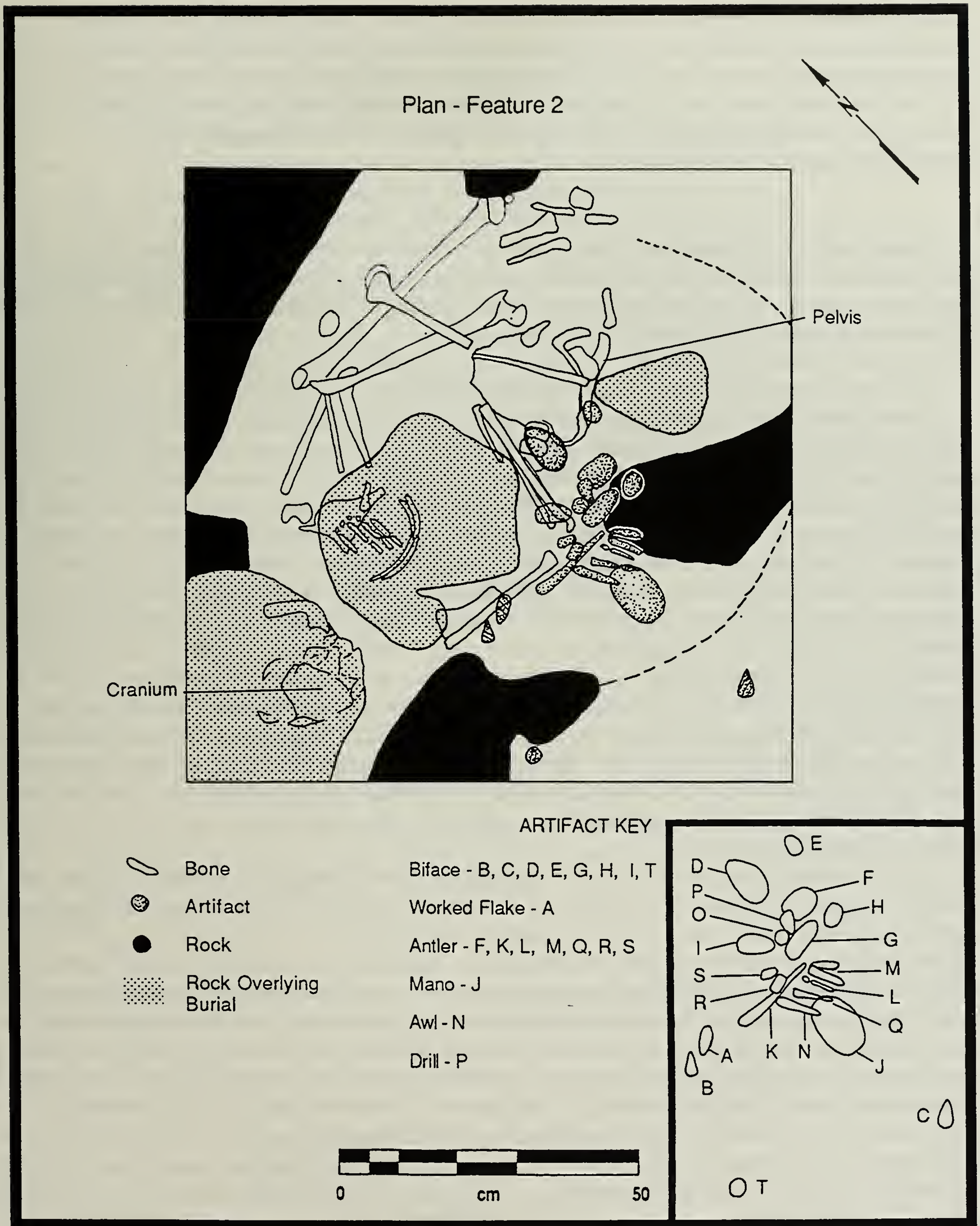


Figure 29. Sadie's Cave Feature 2 Burial Showing Location of Major Skeletal Elements and Grave Goods (letter designations).

southeastern rock is part of the fill in the natural drainage depression along the south wall of the cave, while the northeast block is resting on and within basal residuum sediments. Figure 22 shows the only available profile of the feature, consisting of an arc through the western edge of the feature area. Collectively, these plan and profile data indicate that the burial was placed in a shallow basin-shaped grave (20–25 cm deep at most) that was scooped out of the aggrading Stratum 3 surface between two large rock-fall blocks.

Several other large rocks were removed from what was undoubtedly grave fill, and it is likely that these rocks were intentionally placed over portions of the body (pelvis, upper torso and skull). They may have been placed to discourage scavenging animals, and their placement may have had additional meaning in the context of the local belief system. The shaded rocks in Figure 29 are those that were apparently placed over parts of the body.

Human Remains. Removal of sediment from Feature 2 revealed a single primary interment of a young adult. The skeleton was in a flexed position, lying on its left side, with the skull to the west and spinal column oriented generally parallel to the southern cave wall and the edge of the drainage depression at the south side of the cave. It is likely that the body was placed in a shallow basin scooped from the upper rim of the drainage depression. Existence of a depression would have facilitated grave construction at the depression lip. The grave fill is very similar to surrounding Stratum 3 sediments, and also included placement of several large rocks over selected parts of the body. None of these rocks showed any evidence of shaping or evidence of use other than as intentional grave fill. Field determination of age and sex based on observations of nonmetric attributes of the pelvis and epiphyseal closures (using Bass 1971 as a reference) indicated that the individual was probably a young adult female, with age at death between 20 and 25 years. No bone pathologies were identified in the field. After completion of the fieldwork, the skeletal elements were carefully washed and analyzed by Ahler and Eve Anderson Hargrave. Her analysis confirms that the individual was a young adult female, and the age estimate (using a series of metric and nonmetric traits) is 19±1 years. Ms. Hargrave's work included a formal inventory and analysis of the remains, and her report is included in its entirety in a later section.

Postdepositional Transformations. During the course of excavation, it was noted that specific skeletal elements were missing. Though all five lumbar vertebrae were present and the pelvis and sacrum area was intact, no cervical or thoracic vertebrae were recovered in situ. Ribs were represented by only a few anterior fragments. Almost all of the remainder of the skeleton was present, including the complete, though fragmentary, cranium and mandible underlying one of the intentionally placed rocks. It was noted that the original position of the spinal column would have been parallel to and very near the edge of the erosional depression. In addition, isolated, disarticulated skeletal elements had been recovered from the upper portion of Stratum 3 during the excavation of levels 8 and 9 (in both excavation seasons). These remains were not treated at the time as part of a burial because of the fragmentary and disarticulated nature of the elements. Upon examination of the Feature 2 skeletal inventory, it was observed that the remains recovered from higher levels are not duplicated in Feature 2. The disarticulated remains are mainly cervical and thoracic vertebra fragments, ribs and clavicles—all of these elements are missing from the articulated Feature 2 inventory. At least one of these elements (right clavicle) was broken into two fragments while the bone was still very fresh, possibly by mastication. Both fragments were redeposited in the overlying sediments. If water flow through the drainage depression at the south side of the cave was active at and soon after the time of interment, alluvial erosion flow could easily have exposed the

spinal column and articulated elements. These processes could have displaced some of the elements, which were then further disrupted by carnivorous scavengers. Human or animal action may have resulted in secondary deposition of elements higher in the stratigraphic column. This reconstruction of events is consistent with the interpretation, based the consistent slope and condition of the Test Unit 2 strata, that drainage through the southern solution crevice has been active throughout the Holocene and that the depression in the soft sediments along the south side of the cave is a direct result of periodic water flow, ponding and drainage processes.

Grave Goods. Removal of the easternmost shaded rock shown in Figure 29 exposed some of the pelvis bones. While removing sediment from the lower torso and pelvis area, a cache of 19 intentionally placed grave goods was exposed. These were all mapped individually, photographed after exposure of as many items as possible, and assigned individual artifact numbers consisting of the bag number for the feature and consecutive letter suffixes. One additional artifact (Item C) was somewhat isolated from this cache, but it is also interpreted as an intentionally placed grave offering. Finally, one modified antler artifact was recovered from the general fill, and it probably represents a grave offering as well, given that other modified antler was found in the cache of grave goods. The grave goods are shown in their proper spatial relationships in Figure 29, and the appropriate letter suffixed are indicated. The grave goods represent a wide array of finished and unfinished tools. Ground-stone, modified deer antler and bone, and chipped-stone tools are present. Though these items are not functionally or morphologically similar, their collective placement as a cache in a grave offering context suggests that they were conceptualized as a related assemblage of tools by the people who made, used, and deposited the items. The items are described in detail below.

One ground-stone artifact was included in the grave goods. This item (116J; Figure 30) is a formally shaped, combination mano/pitted cobble/hammerstone made from fine-grained sandstone that has been intentionally shaped. The entire margin of the artifact has been pecked to create the smooth oval plan shape; both ends show additional battering from use of the item as a hammerstone. Both major faces are slightly convex and show evidence of use resulting in smoothing and grinding of the faces. Both faces also have a shallow depression at the center, indicating use as an anvil or center-battered cobble as well. Finally, the face shown in Figure 30 has traces of hematite imbedded in the surface. All of the functions of this multipurpose tool can be inferred as various types of processing activities.

Four artifacts that were interpreted as possible handles or hafts were recovered (Figure 31). Item 116-6 (Figure 31a) is a longitudinally split hemicylinder of polished antler which was recovered from general feature fill during screening. All external ridges have been removed through smoothing and polishing of the surface. Item 116F (Figure 31b) is a 6-x-5-cm chunk of cut antler taken from the junction of two large tines. Rough cut marks are present on both ends, and the lower end forms a rough stem or tang. No other modification is present, and the item may be an unfinished handle. Item 116R (Figure 31c) is almost identical to Item 116F in overall morphology and manufacture. However, a tapering cone-shaped socket (9.5 mm in diameter and 26.1 mm deep) has been drilled into the top of the artifact. This type of tapering socket would have easily served as a haft for a bone, wood or chipped-stone tool. Item 116S (Figure 31d) is another possible unfinished handle. It was cut and snapped from a thick segment of antler tine and the surface has been partially smoothed. A raised area near the cut base may be the remnant of a rough hook, or it may represent an unmodified portion of the original antler surface.

Figure 30. Ground-Stone Artifact in Sadie's Cave Feature 2 Grave Goods.

Three antler artifacts represent possible flintknapping tools (Figure 32 a-c). Item 116M (Figure 32a) is a short billet manufactured from an antler beam section. It shows cut marks and evidence of snapping at the base, while the upper end has been battered and crushed, producing several rounded facets on the worked surface. The shaft surface may have been smoothed by handling, but has not been otherwise modified. Items 116L and 116Q are conjoinable fragments of the same antler tine (Figure 32b). This artifact shows minor faceting at the tip which may represent use as a flintknapping tool. No other cut marks are visible, and the rough surface indicates that item was snapped from a tine low on the rack. Item 116K (Figure 32c) is another possible antler-tine flaking tool that shows cut marks at the base of the smooth tine surface and minimal crushing of the distal end. All of these items are interpreted as flintknapping tools, and all would be useful for resharpening and maintaining the edges of the chipped-stone tools that were also included in the grave goods.

One bone awl (Item 116N; Figure 32d) was recovered. This artifact is manufactured from a white-tailed deer metatarsal that has been split, scraped and polished to produce a fine, needle-sharp tip. This tool would be used to perforate soft materials or possible to aid in manufacture of basketry or other woven goods.

Figure 31. Sadie's Cave Feature 2 Grave Goods—Handles and Potential Handle Preforms: a, Polished antler fragment; b, cut antler chunk; c, cut and socketed antler handle; d, antler tine segment handle.

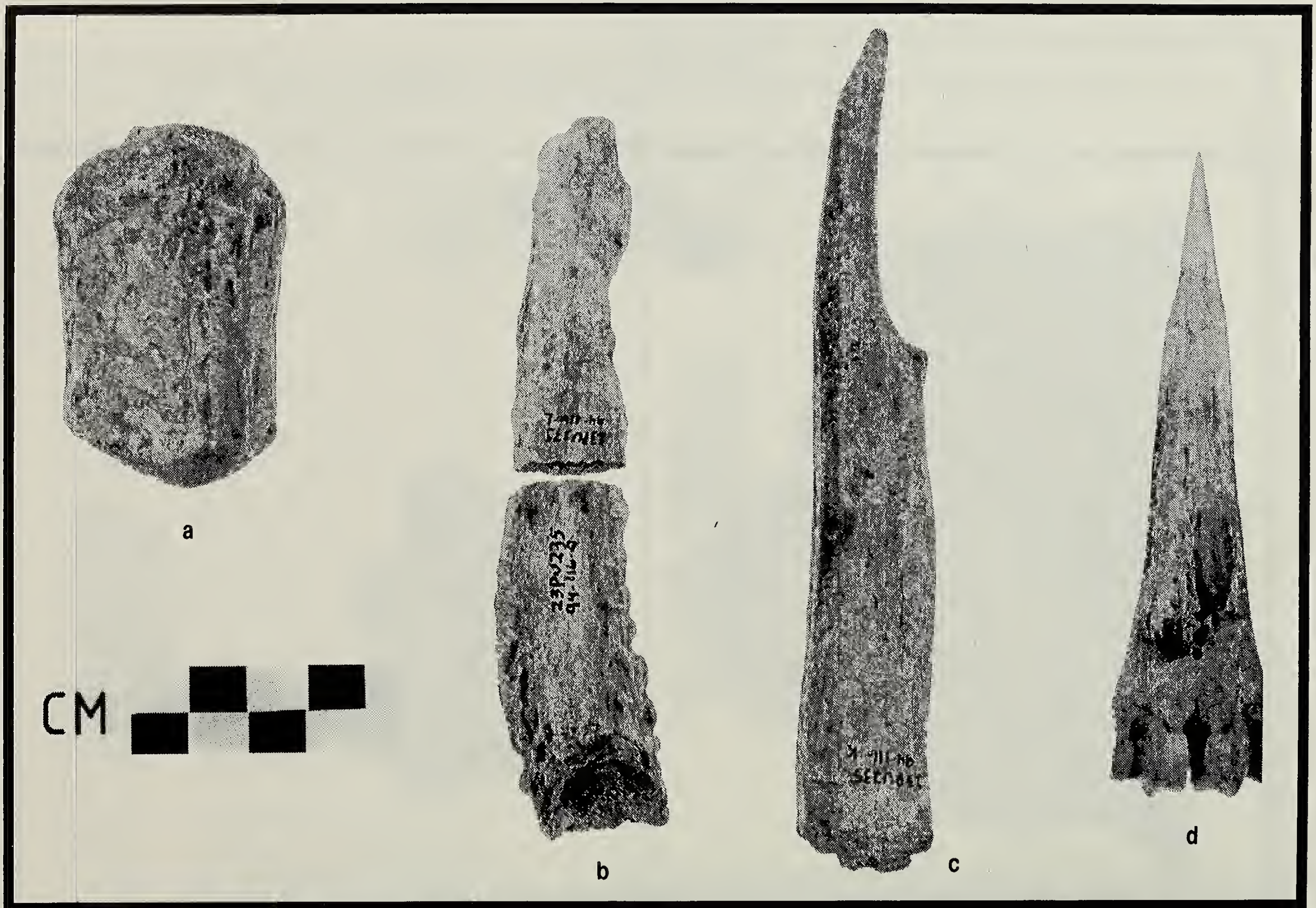


Figure 32. Sadie's Cave Feature 2 Grave Goods—Flintknapping Tools and Bone Awl: a, antler billet; b-c, antler tine pressure-flaking tools; d, deer metatarsal bone awl.

Four bifacially flaked items are interpreted as possible knives or as unused cutting tools (Figure 33). Item 116B (Figure 33a) is a bifacial tool with slightly crescent shape and rounded distal and proximal margins. One lateral margin is concave and the other is convex; the concave margin shows evidence of resharpening in the form of secondary flakes. The proximal end is slightly ground and indicates hafting. The distal end is steeply beveled and rounded, suggesting that it was used as a scraper or gouge along with its other potential uses as a cutting tool. Item 116C (Figure 33b) is a thin biface fragment which has been snapped at the base. It may have been included as a preform or blank; no use-related damage was evident on the edges. Items 116I (Figure 33c) and 116G (Figure 33d) are thick bifaces that also show no evidence of use-related wear.

Four bifacial scrapers were included in the grave good assemblage (Figure 34). Item 116D (Figure 34a) is a large teardrop-shaped bifacial scraper with a steeply beveled distal margin that shows evidence of multiple use and resharpening episodes. The long contracting stem shows light grinding and other evidence of preparation of the tool for hafting. Item 116E (Figure 34b) is a smaller version of Item 116D. Shallow notches in the lateral margin and more pronounced grinding on the proximal end indicate hafting preparation of the artifact. Item 116H (Figure 34c) is an end scraper with a square stem for hafting. The distal margin has been reworked and formally shaped into a steeply beveled scraping edge. Item 116O (Figure 34d) is almost identical to Item 116H. Part of the lateral margin has been snapped to facilitate hafting, and some cortex remains near the center of the item. All of these bifacial scrapers show evidence of recent resharpening of the working edges, which has removed most traces of use-related damage and polish. However, all of the items were used for some time after resharpening, since light damage was detected at low and high magnification on all working edges. These items were apparently placed with the burial while they were in usable condition.

Finally, three other unique modified items were included in the cache of grave goods (Figure 35). Item 116A (Figure 35a) is a large, utilized bifacial thinning flake that shows evidence of intensive use on soft material in the form of rounding and polish on the distal margin. This item may have been intentionally shaped to facilitate hafting or manual prehension; a snap fracture is visible on the left lateral margin of the contracting proximal part of the flake. Item 116P (Figure 35b) is a bifacial drill with a heavily ground, contracting-stem base. The item is either unused or was resharpened just before inclusion in the burial; only occasional isolated areas of possible use-related damage were visible under low magnification (less than 60x). Still, the likely function of the artifact for rotary perforation of durable material can be inferred from its overall morphology. Item 116T (Figure 35c) is a thin biface fragment that shows evidence of breakage and possible recycling. The roughly serrated lateral edges suggest use as a cutting or sawing tool, and the pointed proximal margin has been modified by burination. In addition, crushing on opposing lateral margins suggest use of the tool as a splitting wedge.

In summary, the tools included as grave goods with the Feature 2 burial are all functional items. All show evidence of either recent manufacture or resharpening, further supporting the interpretation that these tools were a useful, functional assemblage of artifacts that collectively had meaning in the everyday lives of the people who placed them in the grave. In addition, all of the tools are indicative of manufacturing, processing, or tool maintenance activities. No projectile points were included in the grave; by inference, hunting activities are not represented in the assemblage. Collectively, the assemblage of grave goods suggests activities that have been traditionally inferred by archaeologists as having been performed by women in hunting and gathering cultures. While

Figure 33. Sadie's Cave Feature 2 Grave Goods—Bifacial Knives: a, bifacial knife and end scraper/gouge; b, unused thin biface; c-d, unused thick bifaces.

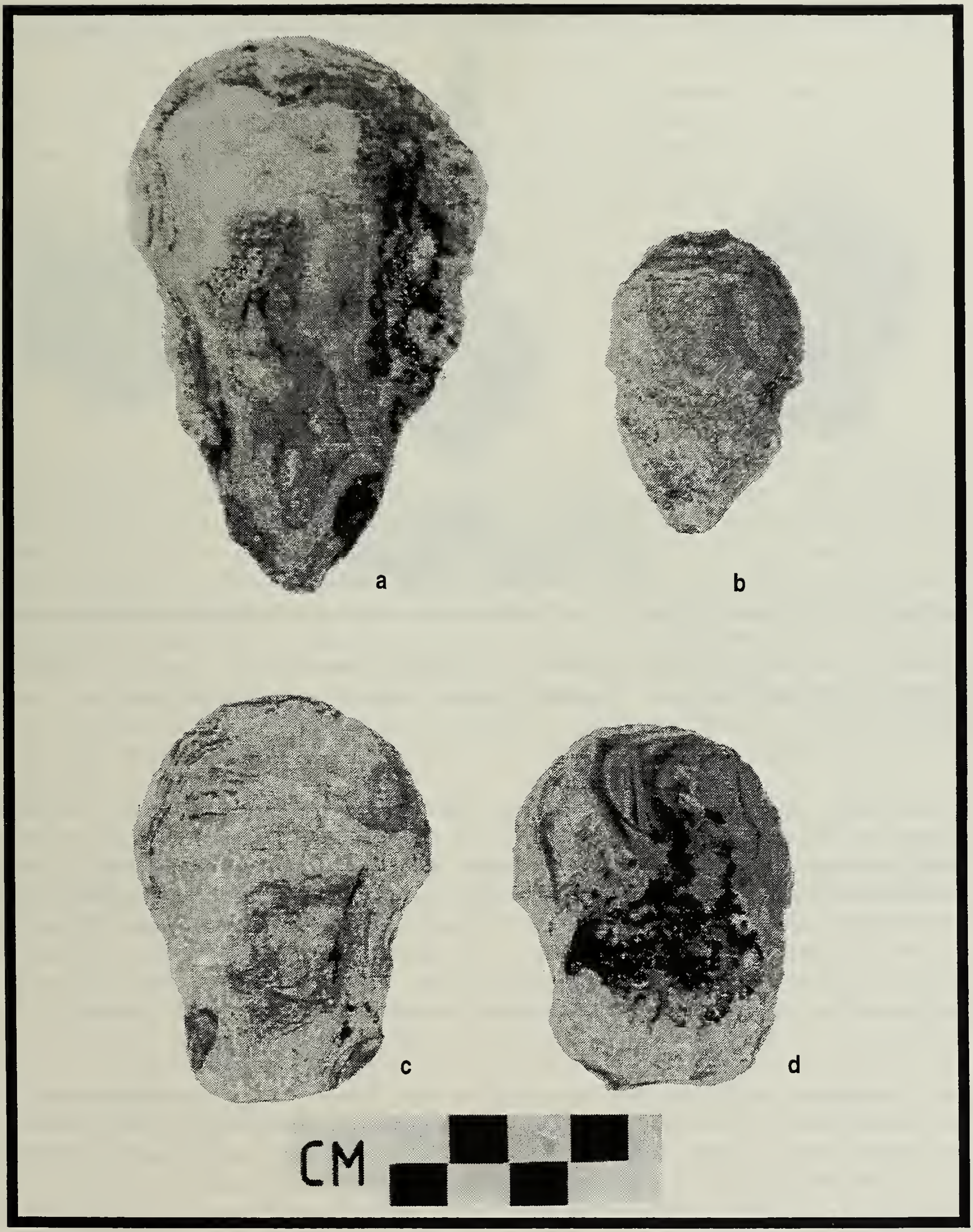


Figure 34. Sadie's Cave Feature 2 Grave Goods—End Scrapers: a-b, teardrop-shape hafted end scrapers; c-d, square-stem hafted end scrapers.

Figure 35. Sadie's Cave Feature 2 Grave Goods—Miscellaneous Items. a) hafted (?) utilized flake; b) bifacial perforator; c) thin biface fragment recycled as a wedge or burin.

there is some ethnographic evidence to support these types of inferences, there is also considerable debate about the validity of extending ethnographic analogs several thousand years into the past. In addition, there is considerable debate over whether the inferred male- and female-oriented activities have been influenced by our own Western cultural traditions or the sex of the interpreter. Setting all of these arguments aside for the moment, the strongest support for interpreting this assemblage as being oriented toward female activities comes from the osteological evidence that the person interred in Feature 2 was female. In this particular case, it is reasonable to interpret the grave goods as representing tools that would be appropriate and necessary for this individual to use in her afterlife.

Summary. The absence of projectile points in the Feature 2 grave meant that there were no temporally diagnostic artifacts. However, radiocarbon assays from Phase II testing provide two uncorrected dates of 7780$\pm$70 B.P., indicating that the carbonized material, and by extension the grave itself, was constructed in the early part of the Middle Archaic period. The presence of a rich grave good assemblage indicates that even at this relatively early date, burial programs were beginning to emerge that incorporated differential treatment of the dead and which indicate social status differentiation as well.

That this behavior was not an isolated case is suggested by the recovery of a nearly identical burial in the lower stratum at Merrell Cave, 23PU64, by McMillan (1965:19–25). This lower stratum is associated with the Early Archaic Tick Creek Complex, and is potentially contemporary with the Feature 2 burial at Sadie's Cave. The Merrell Cave burial was also a semiflexed young adult, but its sex was not determinable. It was also interred in a shallow oval grave, and three sandstone slabs had partially covered the skeleton. Included within the grave as intentional grave goods were a resharpened Rice Lanceolate projectile point and a large teardrop-shaped end scraper similar to those recovered from Feature 2. Other artifacts in the grave which also may represent intentional grave goods include an unmodified, complete deer metatarsal and about 20 large, unmodified chert flakes. These latter items may represent raw material for tool manufacture, and therefore may be similar to the unused bifacial knives and antler handle preforms found with the Sadie's Cave burial.

Analytical Units

Based on the strata and feature descriptions and strata-level correlations, analytical units were defined to guide subsequent tabulations and analyses of specific material classes. These analytical units are composed of one or more excavation proveniences (arbitrary levels, natural levels, features) that are depositionally or pedogenically unique within each test unit. As such, analytical units essentially represent the strata exhibited within each test unit or contiguous test unit pair. Features that were identified and sampled separately in the field were always treated as individual analytical units, though they might later be combined with other materials from the stratum with which they are associated. In the majority of cases, the arbitrary excavation levels did not cross-cut strata, but there are some exceptions, resulting in mixed strata within a single excavation level. In these cases, the level with mixed strata was designated as a separate analytical unit. Additional analytical units were defined for surface materials and for materials from mixed stratigraphic contexts (such as wall scrapings) from a single test unit.

The analytical units are the basic unit of identification and description used to conduct sedimentary, paleoenvironmental, lithic, ceramic, faunal, and botanical analyses. Use of analytical units that are tied to the internal stratigraphy of each test unit or contiguous test unit pair enhances intraunit and interunit comparisons of artifact density, artifact distribution, artifact diversity, inferred site function, and occupational intensity.

Analytical units associated with test units are designated with a combination of the test unit number (TUx) followed by the appropriate stratum (Sx), level (Lx), or feature (Fx) number. In the case of test unit pairs with shared stratigraphy, the number of the deeper test unit with the most complete stratigraphic sequence was used in the analytical unit. Table 7 lists the analytical units and their constituent levels, features, or other proveniences. The analytical units from each test unit are described briefly below.

Table 7. Analytical Units Defined for Sadie's Cave.

Test Unit or Test Unit Pair	Analytical Unit	Constituent Proveniences
1	TU1/S1–4	Test Unit 1, Levels 1, 2, and 3
2/6	TU2/S1	Levels 1, 2, and 3 in both Test Units 2 and 6
	TU2/L4	Level 4 in both Test Units 2 and 6
	TU2/S2	Levels 5, 6, and 7 in both Test Units 2 and 6
	TU2/S3	Test Unit 2, Levels 8, 9, 10, and 13
		Test Unit 6, Levels 8, 9, and 10
	TU2/S5	Test Unit 2, Levels 12 and 14
		Test Unit 6 Levels 11 and 12
	TU2/S7	Test Unit 2, Level 15
	TU2/S6	Test Unit 2, Level 15 supplementary float sample
	TU2/F1	1992 Test Unit 2, Feature 1
	TU2/F2	1992 Test Unit 2, Level 10 and Level 11 float
		1994 TU2 Level 11 and Feature 2
	TU2/F104	F104
	TU2/F112	F112
3	TU3/S1	Levels 1 and 2
	TU3/L3	Level 3
	TU3/S2	Levels 4 and 5
	TU3/S3	Level 6
	TU3/L7	Level 7
	TU3/F4	Feature 4
	TU3/F5	Feature 5
4/5	TU5/S1	Level 1 in both Test Units 4 and 5
	TU5/S2	Test Unit 4, Levels 2 and 3
	TU5/S2A	Test Unit 5, Levels 2 and 3
	TU5/S2B	Test Unit 5, Levels 4 and 5
	TU5/L4	Test Unit 4, Level 4 and Test Unit 5, Level 6
	TU5/S3–5	Test Unit 4, Levels 5–7; Test Unit 5, Levels 6–10
	TU5/L11	Test Unit 5, Level 11
	TU5/S7	Test Unit 5, Levels 12–14
	TU5/S8	Test Unit 5, Levels 15–17
	TU5/F3	Test Unit 4, Level 7 and Feature 3
	TU5/F6	Test Unit 5, Feature 6
	TU5/F8	Test Unit 5, Feature 8
	TU5/F9	Test Unit 5, Feature 9
	TU5/F101	Test Unit 5, Feature 101
	TU5/F119	Test Unit 5, Feature 119
7	TU7/S1	Level 1
	TU7/L2	Level 2
	TU7/S3	Level 3
	TU7/S4	Level 4
	TU7/S5	Level 5

Test Unit 1

Because of the lack of internal cultural stratigraphic differences, only one analytical unit is defined for this test unit (TU1/S1). Most of the few artifacts recovered were derived from Level 2, containing a mixture of Stratum 2 and Stratum 3 sediments. No temporally diagnostic artifacts were recovered from the unit. Since none of the strata can be correlated with strata observed in the test units in the eastern part of the cave, no temporal assignments can be made for the levels or strata in Test Unit 1.

Test Unit 2/6

Eleven analytical units are defined for Test Unit 2. Six of these (TU2/S1, S2, S3, S5, S6, and S7) are defined on the basis of stratigraphy. In most analyses, TU2/S5 and TU2/S7 are combined because they become indistinguishably mixed in the TU6 exposure. However, there are flotation samples from the separate strata 5 and 7, and their analytical integrity is maintained in the analyses of the flotation-derived materials. One analytical unit is composed of a single level (TU2/L4) that includes material from both strata 1 and 2 in almost equal proportions. The remaining analytical units are comprised of individual features. The TU2/F1 analytical unit was defined during analysis of the 1993 test excavation materials; it may not be incorporated into the 1994 analyses. Feature 1 is associated with Stratum 1. Features 2, 104 and 112 constitute the remaining analytical units from Test Unit 2/6. These features are kept separate in the analyses, but are associated with Stratum 3, Stratum 2 and Stratum 1, respectively.

Test Unit 3

Seven analytical units are defined for this test unit. Three of these (TU3/S1, S2 and S3) are defined through stratigraphic association, while two others are levels that contain materials from mixed stratigraphic contexts. TU3/L3 contains material from both strata 1 and 2, and TU3/L7 contains material from strata 4 and 5, with minor amounts of material from Stratum 3 also included. Two analytical units are associated with individual features. Both Features 4 and 5 are associated with Stratum 1 but are maintained as separate analytical units.

Test Unit 4/5

Sixteen analytical units are defined for this test unit pair. Seven of these are stratigraphically defined (TU5/S1, S2, S2A, S2B, S3-5, S7, and S8). Some analyses may separate materials derived from strata 2, 2A and 2B, but these are in fact stratigraphically similar and can be combined. Two additional analytical units represent levels with mixed stratigraphic associations. TU5/L4 is composed of the levels with mixed materials from Stratum 2 (or 2B) and underlying Stratum 3-5. TU5/L11 is composed of mixed Stratum 3-5 and Stratum 7 materials. The remaining seven analytical units are associated with individual features. Feature 6 is at the Stratum 2A/2B boundary, while Features 7, 8 and 101 are associated with Stratum 2B. All of these can be generally associated with Stratum 2. Features 3 and 9 are associated with Stratum 3-5, and Feature 119 is at the Stratum 7/8 boundary.

Test Unit 7

Five analytical units are defined for this test unit. Four of them (TU7/S1, S3, S4, and S5) are based on natural strata. The remaining analytical unit (TU7/L2) is an arbitrary level containing a mixture of material from strata 1 and 2. While features are present in this test unit, they were recognized only in profile after excavation, and none of them were sampled separately.

Sediment Analyses

To facilitate interunit stratigraphic correlations and help create site-wide, time-stratigraphic units that would be useful for later analyses, soil samples taken after excavation from all major strata and selected minor substrata within each test unit were analyzed. Both soil chemistry and particle size analyses were performed, and the results are discussed below.

Soil Chemistry

To identify attributes that might be shared among contemporary strata, a series of standard chemical analyses was performed on selected samples extracted from each test unit or test unit pair. Samples massing approximately 20 g were sent to Ingram Soil Testing Service, Sullivan, Illinois, for determination of concentrations of total phosphorus (in the form of PO_4 phosphate), potassium, magnesium, and calcium and determination of sediment pH and percent organic matter (OM). Table 8 shows the results of these chemical analyses. Based on these results, several general observations can be made regarding the overall soil chemistry environment within Sadie's Cave and potential stratigraphic correlations among test units.

First, pH decreases with depth in all test units, with the greatest change in pH values associated with the changes between Holocene colluvial sediment and underlying reworked Pleistocene residuum. However, pH values show little systematic variability from front to back in the cave. The pH values for the TU5-6-2-3-7 sequence shows no systematic changes when the top stratum in each test unit is compared or when underlying strata are compared. In addition, the overall range in pH does not vary substantially among test units. The pH values for major strata in TU5 and TU6 have the highest range (8.4 to 8.9 and 8.5 to 8.9, respectively), but there is considerable overlap with the pH range in all other test units (8.1 to 8.7). The overall high pH in all strata is consistent with our field observations of good preservation of bone and shell remains in all strata, even in the reworked and in situ basal residual deposits.

Second, percent OM also decreases steadily with depth in all test units. Like the pH values, percent OM also shows little change across test units when strata in the same relative stratigraphic position are compared. The only general trend observed is that TU7 has lower OM content than other test units. The TU7 OM values range from 0.6 to 1.9 percent, while valued for major strata in all other test units range between 0.8 and 3.0 percent.

Phosphorus content is variable across test units and among strata at in the same relative position in the depositional sequence. TU5 generally had the highest phosphorus content for all strata, and it appears that there is a general decrease in phosphorus content toward the back of the cave. However, this trend incorporates much variability among individual samples, and little

Table 8. Summary of Soil Chemistry Analyses for Sadie's Cave Test Units and Strata.

Stratum	pH	%OM	Phosphorus (ppm)	Potassium (ppm)	Magnesium (%)	Calcium (%)
Test Unit 5						
1	8.8	2.9	157	816	0.286	2.384
2A	8.9	2.9	99	364	0.264	2.328
2B	8.8	2.7	116	136	0.264	2.896
3	8.8	2.0	93	248	0.238	1.874
3/5	8.7	1.9	117	112	0.202	1.470
7	8.6	2.0	123	140	0.190	1.086
8	8.4	1.3	121	356	0.234	0.927
Test Unit 6						
1A	8.7	3.1	106	124	0.242	2.896
1B	8.8	2.8	81	192	0.268	2.728
1C	8.8	2.7	118	132	0.260	2.088
1G	9.0	3.4	149	260	0.286	2.512
2	8.9	1.8	131	132	0.213	1.151
2C	8.8	1.9	118	96	0.204	1.556
F111	8.9	1.7	147	180	0.252	2.472
3	8.7	1.5	132	132	0.209	1.300
5/7(NE)	8.6	1.1	103	200	0.242	0.927
5/7(SE)	8.4	1.2	81	172	0.136	0.820
6	8.5	0.8	57	176	0.190	0.778
Test Unit 2						
1A	8.5	2.7	26	128	0.192	7.072
1B	8.5	2.8	35	116	0.183	3.920
1C	8.6	2.4	45	128	0.190	3.448
1D	8.6	2.4	8	100	0.149	6.992
1E	8.5	2.1	6	88	0.136	8.176

Table 8. Concluded.

Stratum	pH	%OM	Phosphorus (ppm)	Potassium (ppm)	Magnesium (%)	Calcium (%)
Test Unit 2 (continued)						
1F	8.7	2.8	96	104	0.260	3.580
2	8.6	2.3	59	132	0.179	1.832
2A	8.7	1.8	96	140	0.200	1.748
2B	8.6	2.0	26	116	0.136	3.196
3	8.6	2.1	59	152	0.160	0.991
3A	8.4	1.9	116	156	0.160	1.278
5	8.0	1.9	62	252	0.164	0.490
7	8.2	0.7	73	204	0.155	0.452
6	8.1	1.8	54	200	0.140	0.421
Test Unit 3						
1(NE)	8.6	2.9	71	88	0.226	1.470
1(SE)	8.7	2.8	67	116	0.246	2.512
1(SW)	8.6	3.0	39	100	0.190	1.768
1(Average)	8.63	2.90	59	101	0.221	1.917
2	8.5	1.9	48	136	0.151	1.256
3	8.4	1.8	123	176	0.136	0.474
4	8.1	1.6	109	212	0.180	0.426
Test Unit 7						
1	8.7	1.9	27	116	0.246	2.216
2	8.6	1.8	69	124	0.221	1.470
3	8.4	1.9	66	156	0.181	0.724
4	8.2	1.0	116	208	0.164	0.410
5	8.1	0.7	62	208	0.215	0.378
6	8.2	0.6	42	184	0.194	0.703

systematic variation can be extracted. If phosphorus content is a measure of the relative intensity of human occupation (see Woods 1977, 1988), the values for the Sadie's Cave samples suggest that occupation was highly variable through time and spatially within the cave. This observation is consistent with the interpretation of the Holocene strata as representing gradual accumulations of sediment that incorporate the remains of numerous, short-term, repeated human occupation episodes.

Potassium content showed high variability in the front of the cave, with values ranging from 816 to 112 ppm. However, the general trend is for potassium levels to decrease slightly from front to back within the cave. Another trend is for potassium to increase with depth in the upper Holocene cultural strata. Exceptions to this trend are seen in the high value for TU5, Stratum 1 and the low value for TU6, Stratum 2. Otherwise, within each test unit, potassium levels increase with depth, then drop slightly in the lowest (Pleistocene clay), noncultural stratum (when assayed). This trend is particularly evident in test units 2, 3 and 7. The ranking of correlated strata are shown below for each test unit.

It was anticipated that potassium would be a good indicator of the amount of ash contained in the sediment matrix; ash was in turn viewed as an indicator of the relative intensity of human occupation represented within the major strata. Based on field observations of ash content and the relative frequency of artifacts within each stratum, it was expected that potassium levels would be highest in the uppermost stratum in each test unit and would generally decrease with depth. It was also expected that the potassium values for Test Unit 2 would be highest, resulting from secondary dumping of ash and other refuse near the drainage depression south of Test Unit 2. Neither of the expected trends were observed. It is likely that these unexpected trends result from the high solubility and transportability of potassium as a chemical element within sediment profiles and the high permeability of the upper sediments (see Brady 1974). The highest concentrations of potassium in the sediment column would move downward as potassium was dissolved from younger deposits and transported down in the moist conditions of the cave. The chemical effects of weathering may have little effect on the visual appearance of the sediment, and high ash content may still be observable even though the potassium has been leached from the sediment and redeposited lower in the profile.

Magnesium levels generally decrease from front to back in the cave. In addition, concentration generally decreases with depth, though there is a great deal of variation among strata that are at the same their relative profile position. Stratum 1 has consistently higher levels of magnesium than any other stratum within a given test unit, and the stratum immediately overlying the reworked Pleistocene residuum (usually Stratum 3 in most test units) generally shows the lowest concentrations. However, magnesium levels in the strata composed of reworked Pleistocene deposits (TU2/Stratum 5–7; TU6/Stratum 5/7; TU3/strata 4 and 5, TU7/strata 4 and 5) often have higher values than the immediately overlying Holocene sediments. Sediments with greater permeability often show greater chemical leaching (Brady 1974), and the reworked sediments are silty clay loams, while the overlying sediments are loams to sandy loams. This also explains the high levels of magnesium in the TU2/Stratum 6 sample of in situ Pleistocene residuum—it is least permeable, so loss through leaching would be relatively low in this environment. To adequately examine differential weathering regimes, it would be necessary to run a separate analysis of calcite and dolomite content using a Chittick apparatus. Given the dolomitic nature of the cave environment in general, this analysis would probably be redundant with the magnesium data already at hand.

Calcium concentrations are high due to the dolomitic nature of the cave and the tendency for calcium to be readily incorporated into sediments either in solution or as secondary precipitates. Calcium content generally decreases from front to back in the cave, though there are high anomalies in TU2/Stratum 1 and minor variations in strata 2 and 3 values for some test units. In addition, calcium content decreases uniformly with depth in each test unit. These data and trends indicate a generally continuous weathering process which has chemically removed increasing amounts of calcium from the sediments. The older sediments have been subjected to more chemical leaching.

Finally, calcium:magnesium ratios were calculated based on the percentages shown in the raw data. These values show the same trends as noted in the calcium data. Little additional information is available concerning weathering regimes or intensities.

In summary, the chemical signatures explored here generally show two major trends within and among test units. First, most of the chemical signatures examined here show decreasing values with depth within a given test unit. This finding is consistent with longer durations of chemical weathering for the lower strata in this slowly aggrading sedimentary environment. Second, many of the chemical signatures show decreases from front to back within the cave when values for strata at the same relative stratigraphic position are compared. This finding is consistent with the observation of increasing moisture in the sediments as one moves from the relatively dry cave mouth area to the footslope of the Holocene sediment cone. Increasing soil moisture will generally result in increased chemical activity and increased leaching of water-soluble elements and compounds from the sediment. None of the strata or sets of strata in similar profile positions showed evidence of consistently high chemical anomalies that might correlate specific strata among test units or that might indicate major changes in the rates of deposition or chemical weathering within the Holocene.

Particle Size Analysis

To further compare the stratigraphic series represented at the site and build potential stratigraphic correlations between test units, analysis of particle size was performed on samples taken from major strata and selected minor substrata in all test units. Most of these samples were included in the above analysis of soil chemistry. A stratigraphic column is represented for all test units except for test units 1 and 4.

The samples were analyzed by Dr. Cynthia L. Balek at the Department of Geography Soils and Geomorphology Laboratories, University of Illinois. Dr. Donald L. Johnson graciously provided access to the chemicals and laboratory equipment needed for these analyses. Standard particle size analytical procedures were followed. The entire sample was first air-dried. Each sample was crushed using a mortar and pestle, and the sample was passed through a 2000 μ (2 mm) sieve. The weight of the fraction retained in the sieve was added to that of the fraction passed through the screen to provide the total sample weight. The weight of the >2000 μ fraction was divided by the total weight x 100 to yield the percentage of the sample that was >2000 μ (shown in Table 9).

The pipette method of particle size analysis recommended by the Soil Survey Staff (1972), with modifications developed by the Western Illinois University Paleogeography Laboratory (Caspall n.d.), was used to determine distribution of the <2 μ clay fraction, the 2–20 μ fine-medium silt fraction, and the 20–50 μ coarse silt fraction. Four separate sand fractions (50–100 μ very fine sand; 100–250 μ fine sand; 250–500 μ medium sand; 500–2000 μ coarse and very coarse sand) were

Table 9. Summary of Particle Size Analyses for Sadie's Cave Test Units and Strata.

Stratum	Clay <2μ	Fine/Medium Silt 2–20μ	Coarse Silt 20–50μ	V.F. Sand 50–100μ	Fine Sand 100–250μ	Medium Sand 250–500μ	Coarse/V. Coarse Sand 500–2000μ	Gravel >2000μ	Textural Classification
Test Unit 5									
1	3.6	13.0	6.9	9.2	24.9	30.2	12.2	13.5	Loamy sand
2A	3.8	15.0	7.7	9.2	25.2	29.0	10.1	16.5	Sandy loam
2B	4.2	17.1	8.6	9.3	23.8	27.6	9.4	16.0	Sandy loam
3	6.8	24.0	10.3	8.1	19.3	22.2	9.3	12.8	Sandy loam
3/5	8.6	28.6	10.1	6.7	17.2	20.4	8.4	17.1	Sandy loam
7	9.6	28.0	9.3	6.5	17.4	20.3	8.0	12.4	Sandy loam
8[a]	26.5	35.1	8.1	5.5	11.6	8.8	4.4	1.2	Loam
9[b]	27.0	27.2	5.9	12.4	19.5	6.6	1.4	2.3	Loam/clay loam
Test Unit 6									
1A	5.6	18.9	6.8	7.2	21.7	27.3	12.5	10.5	Sandy loam
1B	3.3	14.3	7.9	10.5	25.3	29.0	9.7	16.5	Loamy sand
1C	3.6	13.9	8.0	9.9	22.2	30.8	11.6	24.1	Loamy sand
1(Average)	4.2	15.7	7.6	9.2	23.1	29.0	11.3	17.0	Sandy loam
2	12.0	23.9	6.9	5.1	19.0	24.6	8.5	22.2	Sandy loam
2C	11.4	22.1	7.4	6.0	19.6	24.8	8.7	5.8	Sandy loam
3	9.9	26.3	8.9	5.8	20.0	23.4	5.9	1.4	Sandy loam
5/7[a]	26.6	25.7	5.6	4.5	15.2	17.0	5.4	3.3	Loam

Note: All values are given in percent. Values for <2 μ through 500–2000 μ fractions are based on percentage composition by weight of a standard 20-gram sample from each stratum. Values for the >2000 μ fraction are based on percentage by weight of the total available sediment sample.

Table 9. Concluded.

Stratum	Clay <2μ	Fine/Medium Silt 2–20μ	Coarse Silt 20–50μ	V.F. Sand 50–100μ	Fine Sand 100–250μ	Medium Sand 250–500μ	Coarse/V. Coarse Sand 500–2000μ	Gravel >2000μ	Textural Classification
Test Unit 2									
1A	5.5	29.9	7.6	7.2	19.0	20.2	10.6	18.4	Sandy loam
1B	13.1	23.5	6.3	5.1	20.6	25.1	6.3	9.7	Sandy loam
1C	17.2	23.9	6.0	5.3	19.5	22.9	5.2	12.2	Sandy loam
2	17.0	24.9	6.3	4.3	17.4	22.5	7.6	8.8	Loam
3	18.1	27.5	6.5	3.5	15.9	21.3	7.2	4.7	Loam
5[a]	28.0	38.5	7.8	2.8	8.7	9.3	4.9	19.5	Clay loam
7[a]	26.5	38.4	8.4	2.7	8.9	9.5	5.6	5.7	Loam
6[b]	34.7	28.9	3.9	5.5	14.2	10.1	2.7	24.1	Clay loam
Test Unit 3									
1	12.2	28.2	7.9	5.1	15.9	20.6	10.1	21.4	Loam
2	18.3	27.8	7.1	3.8	14.5	18.3	10.2	8.1	Loam
3	24.1	31.5	7.3	2.7	12.7	16.0	5.7	7.1	Loam
4[a]	33.6	31.8	3.9	2.4	10.2	12.8	5.3	32.5	Clay loam
5[a]	39.0	24.0	3.1	1.4	11.2	14.4	6.0	36.2	Clay loam
Test Unit 7									
1	11.1	29.5	9.7	7.2	15.9	18.7	7.9	7.8	Loam
2	14.0	31.0	8.7	5.5	14.6	18.5	7.7	7.9	Loam
3	21.8	30.7	8.2	3.4	13.1	17.0	5.8	20.6	Loam
4[a]	36.0	25.9	3.6	2.5	11.4	13.7	6.9	39.6	Clay loam
6[b]	36.7	26.9	3.3	3.4	12.6	13.1	4.0	1.8	Clay loam

[a] Denotes a stratum interpreted as basal residuum that have been reworked during the early Holocene
[b] Denotes a stratum interpreted as in situ basal Pleistocene residuum

obtained by dry sieving. USDA particle size classifications were used to differentiate and name the various sand, silt and clay fractions.

Twenty grams of the <2000 μ fraction were pretreated with 30 percent hydrogen peroxide solution to remove organic matter, followed by dispersal for 18 hours in a solution of sodium metaphosphate buffered with sodium carbonate. The samples were then mixed in an electric milk shaker for five minutes. After mixing, the sample was passed through a #300 mesh (50 μ) screen prior to pipetting to collect the sand fraction. The sand fraction was oven-dried then placed into a set of nested sieves of the appropriate mesh size and vibrated for five minutes in a Cenco shaker at a setting of 8. The percent by weight of each <2000 μ fraction was calculated as a percentage of the sediment sample.

The interior and exterior topography indicated that the vast majority of sediment in the eastern third of the cave had been deposited during the Holocene by aggradation of a small colluvial cone on a bluff ledge near the cave mouth. Colluvial and surface washing processes had probably also reworked some of these deposits, transporting sediment farther west into the cave. The colluvial cone sediments would be composed of a combination of redeposited silt loam and gravels that had been eroded from the bluff crest, shoulder and upper backslope; these sediments were expected to yield highly variable particle sizes. Within the cave itself, roof spalls and grain rain would also contribute sand and gravel-size particles to the aggrading sediment matrix. It was expected that most of the sediment samples derived from the aggrading Holocene sediment cone (not footnoted in Table 9) would show particle size distributions that were consistent with a combination of colluvial and grain-rain sediment sources. Relatively high but variable percentages of gravel and coarse sand should be present, representing grain rain contribution to the sediment matrix. The <2 mm fraction should have a particle size distribution indicative of redeposition of the loam and silt loam soils that were eroded from the upper bluff slopes. It was further expected that because of the absence of pedogenesis within the cave environment in general, there would be no "clay bulge" in the lower strata of any sequence. There should be a marked increase in both clay and >2 mm particles in the lowest part of each sequence, corresponding with the reworked and in situ basal residuum sediments (marked in Table 9 with footnotes [a] and [b], respectively). Finally, of particular interest in this analysis was identification of any samples that showed high percentages of fine-medium silt. If high silt proportions were consistently present in the middle or lower portions of the Holocene stratigraphic sequences, this could be interpreted as evidence for eolian silt deposition during the mid-Holocene.

Table 9 lists the results of the particle size analysis. Both Ahler and Balek have drawn some observations from these sample trends, and these are summarized briefly. First, the overall texture classification of most of the Holocene sediment cone samples is in the loam, sandy loam or loamy sand classes. None were classified as silt loams. The field determination of texture was generally finer than the particle size analyses indicate. This finding also suggests that most of the clay fraction in the silt loam soils that comprise the bluff crest primary source for the colluvial cone sediments is being transported farther down the bluff slope and is not part of the sediment accumulation in Sadie's Cave.

Second, there is generally a bimodal distribution in the particle size percentages in all of the samples. Cumulative frequency curves of particle size percentages were not compiled for these samples (the usual method of comparing particle size distributions), and there is some debate among

geomorphologists concerning interpretation of these data in terms of inferred transport-depositional processes. Regardless, the bimodal distribution is consistently present in all samples, though subdued in its expression in the lower residuum samples. This observation suggests that particle size distributions are not necessarily good indicators of transport depositional processes for the Sadie's Cave environment. Balek notes that she has observed bimodal particle size distributions in samples extracted from Illinoisan age till, sand beds within till, high-terrace alluvial deposits on Fort Leonard Wood, colluvium samples, and a loess sample from Fort Leonard Wood. All of these have peaks in the fine-medium silt and the fine-medium sand ranges, even though they were collected from deposits of widely varying depositional regimes. The only conclusion to draw from these data is that the bimodal distributions of these samples is consistent with the textural classification of many of the samples as loams or sandy loams. Specific transport-depositional processes cannot be interpreted from these data.

Third, as expected, the gravel (>2 mm) fraction is well-represented in most samples but is also highly variable within both the Holocene and residuum sample sets. The gravel-sized particles are most likely introduced through grain rain and roof breakdown processes within the cave itself and provide a consistent source of large particles. This internal source of larger particles may also have contributed to the medium sand peak that is consistently present in all particle size distributions.

Fourth, only the samples from test units 5 and 6, which are closer to the mouth of the cave, showed any evidence for increasing proportions of fine-medium silt in the samples derived from the lower Holocene sediment cone strata. In TU5, fine-medium silt increases from 17 to 24 percent between strata 2B and 3; in TU6, there is an increase from 15.7 to almost 24 percent between Stratum 1 (average of three samples) and Stratum 2. In addition, TU5 samples show a slight increase in the coarse silt fraction in strata 3/5 and 7; these strata were deposited during the mid-Holocene, based on radiocarbon assays (see below). This "silt bulge" may be interpreted as evidence for increasing eolian deposition near the cave mouth during the mid-Holocene. However, if eolian silt was being added to the deposits, these sediments apparently were not blown very far into the cave. Secondary reworking of the deposits by percolating water and minor pedogenic processes could easily mask any effects of systematic mid-Holocene eolian silt deposition. Balek notes that medium silt:coarse silt ratios are better indicators of loess deposition than the raw particle size percentages shown here. Unfortunately, we did not extract medium silt as a separate particle size grade, and it would be difficult to interpolate medium silt percentages from the combined fine-medium silt fraction data at hand.

We expected that the particle size distributions within a given test unit column would not show evidence of an argillic horizon associated with pedogenic processes because of the general absence of soil horizonation within the cave environment. Instead, we predicted an increase in clay percentage would be associated with the reworked and in situ residuum strata. Table 9 shows that the most noticeable increase in clay percentage is associated with these lower depositional regimes. However, most stratigraphic sequences also show a gradual increase in clay content with depth; in several cases there is sufficient change in percent clay to warrant classification of the stratum as an argillic horizon on technical grounds. However, even though the clay content increases, these strata lack other attributes of a developing argillic horizon such as moderately well-developed subangular blocky to blocky structure or presence of argillans (clay skins) on soil peds. The clay increases are presently interpreted as evidence for continuing transport of smaller particles downward within the generally porous, poorly compacted and loamy sediment column through groundwater percolation

processes. There is little other evidence for soil horizonation within the cave environment, largely because of the absence of plant and microfauna bioturbation.

Continuing transport and modification of the deposits is further indicated by examination of spatial trends among test unit sequences. These trends are especially pronounced in the upper strata in all test units, and are expressed to a lesser degree in the lower Holocene strata as well. However, all of these are generalized observations, and there is minor variability in all of the test unit sequences. In general, soil texture classes of all become finer from Test Unit 5 (located near the cave mouth and near the apex of the colluvial sediment cone) to Test Unit 7 (located well within the cave at the footslope of the colluvial sediment cone). Comparing the particle size classes in the sequence of test units 5-6-2-3-7, there is a general increase in clay content from the mouth of the cave to the back. Fine silt also shows a general increase in this direction, though the trend is not as robust. There is little change in the coarse silt fraction, but very fine sand to coarse sand fractions all show decreasing percentages from front to back. Collectively, these trends suggest that fine sediments have been and are continuing to be eroded from the apex of the colluvial cone and are being redeposited downslope. This trend indicates that sedimentologic processes resulted in sorting of particles within the cave environment. Combined with the increase in clay content with depth in the all test units, these findings suggest that the processes that are sorting the particles are operating in both vertical and horizontal dimensions and that these processes have been part of the Sadie's Cave environment throughout the Holocene.

Summary

While the sediment analyses did not identify specific depositional events or determine that specific depositional processes were dominant during particular time periods, these investigations have pointed to some trends that may be more fully explored through analysis of other material classes. Of most importance is the possibility that there was sufficient change in the local environment during the middle Holocene that local vegetation regimes and sedimentation processes were affected. The increase in silt content in some of the middle Holocene strata suggests that the local effects of the Hypsithermal Interval may have been relatively severe. Analysis of other data sets, especially the terrestrial gastropods and mussel shells, may provide additional evidence of the nature and magnitude of mid-Holocene paleoenvironmental changes. These topics will be more fully explored in later analyses.

Chronology

Two methods of age determination were employed to provide temporal control of the Sadie's Cave strata. First, general age and cultural affiliation of some components was determined through typological comparisons of temporally diagnostic projectile points and ceramics to previously defined types within the region. The provenience context and age or cultural affiliation of each diagnostic artifact was recorded. These data provided general chronological sequences that can be compared to the radiocarbon assays or bracketing assays for the same strata. This comparison aided in the construction of time-stratigraphic units and reinforced the interpretations of instances of projectile point recycling.

Second, radiometric age determinations for specific provenience contexts were obtained through radiocarbon assay of carbonized plant remains. Prior to assay, botanical analyses were conducted on samples of suitable mass and material that were to be used for radiometric dating. Twelve radiocarbon assays were obtained from controlled stratigraphic contexts, some of which were from feature contexts and some of which were from general levels that were assigned to specific correlated strata. Combined with the five assays previously obtained during the Phase II investigations, 17 radiocarbon assays are associated with the site. This makes Sadie's Cave one of the best-dated stratigraphic sequences in the region and provides the basis for interunit stratigraphic comparisons and constructing time-stratigraphic units that enhance diachronic analysis of the remains.

The more general temporal assessment of the point typology is discussed first, followed by discussion of radiocarbon assays. Ceramic artifacts are described in detail in a later section.

Temporally Diagnostic Artifacts

Temporally diagnostic artifacts recovered from Sadie's Cave include both ceramic artifacts and chipped-stone projectile points. All of the ceramic artifacts, except for a single small sherd, were recovered from the upper stratum in all test units. Collectively, these artifacts indicate that the upper stratum contains evidence of Late Woodland occupation; other time periods may also be represented, based on the radiocarbon assays and projectile points also recovered from these strata. Because they represent such a narrow temporal range and are restricted to a small portion of the stratigraphic sequence, the ceramic artifacts are described in detail in a later section. The following paragraphs focus on discussion of the temporally diagnostic projectile points.

A total of 15 temporally diagnostic projectile points or point fragments was recovered during the Phase II testing and the present investigations. Points were recovered from all test units except for test units 1 and 4. In addition, almost all of the major strata yielded at least one projectile point, providing another possible means of correlating strata among the test units. Projectile points are described and discussed in stratigraphic order from youngest to oldest within each test unit; test units are arranged from front to back of the cave.

Test Unit 4/5

Test Unit 4 produced no projectile points, but Test Unit 5, with a common stratigraphic sequence, produced two specimens. Level 7 (Stratum 3–5) yielded one corner-notched fragment with rounded ears, slightly concave base, a serrated blade, and evidence of moderate grinding on the haft element (Figure 36a). This specimen is similar to Kirk Corner-notched points (Justice 1987), but the notches are larger than usual for this point type. Comparison of this specimen to others illustrated in regional literature sources indicate that its morphology and attributes compare most favorably to specimens that Kay (1980) called Johnson points (Category 26). This point type is also attributed to the Early to Middle Archaic period. Other possible morphological correlates are McMillan's (1965) CN7 type and Kay's (1980) Category 14 type. The former is assigned to the Late Archaic period while the latter type is represented in the Late Archaic through Late Woodland strata at Rodgers Shelter. The closest morphological correlate is the Johnson point type. However, if this assignment is correct, this specimen has been displaced from its original context of manufacture and use and has been redeposited in Late Holocene Stratum 3–5 sediments.

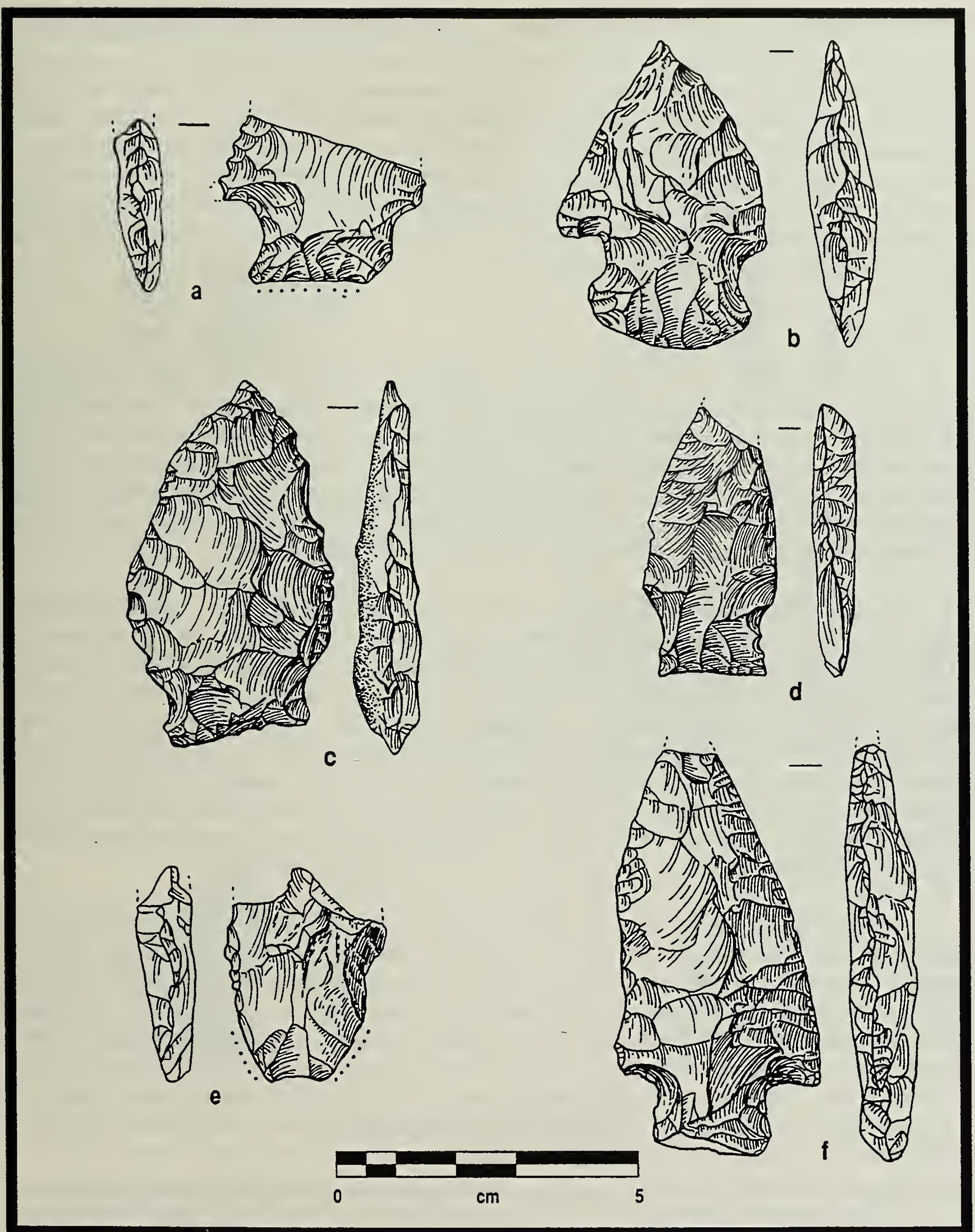


Figure 36. Temporally Diagnostic Projectile Points from Sadie's Cave: a, possible recycled Early Archaic Johnson point (TU5/S3-5); b, Late Archaic CN3 point (TU5/S3-5); c, Big Creek or rough Late Woodland Rice Side-notched point (TU2/S1); d, Late Woodland Rice Side-notched point (TU2/S1); e, Middle Woodland (?) contracting stem base (TU6/S1); f, Late to Terminal Archaic Verkamp or Category SS4 point (TU6/S1).

The second specimen from Test Unit 5 (Figure 36b) is corner-notched/expanding stem with rounded ears, excurvate base, and acuminate tip. This specimen is morphologically most similar to Early-Middle Archaic Williams (Category 29) points described by Kay (1980), and to Late Archaic-Late Woodland Category CN3 points described by McMillan (1965). McMillan (personal communication 1994) observed that the acuminate tip was a sharpening pattern most often associated with a variety of Late Archaic point types, including Afton Corner-notched and other expanding stem points commonly recovered in Late Holocene contexts in the Ozarks. Given the stratigraphic context in dated Late Archaic contexts and the presence of the acuminate tip, this artifact is assigned to the Late Archaic-Late Woodland CN3 category.

Test Unit 2/6

The 1993 Phase II test excavations in Test Unit 2 produced two projectile points from Stratum 1 contexts. The specimen in Figure 36c was previously described as a possible Big Creek point assigned to the Late Archaic period (Justice 1987; Morse 1970); subsequent examination of this point indicates that it is probably unfinished, and it may represent a crudely shaped Late Woodland Rice Side-notched point (Chapman 1980; Marshall 1958; McMillan 1965; Reeder 1988). The second point (Figure 36d) compares very favorably to the defined Rice Side-notched type, and its presence is consistent with the Late Woodland radiocarbon assay from this stratum.

Two additional specimens were recovered from Stratum 1 contexts in the 1994 Test Unit 6 excavations. The specimen in Figure 36e is a contracting-stem base fragment recovered from TU6/Level 2 (Stratum 1B) that has been severely damaged by burning after discard. None of the blade element remains, but there are isolated areas on the lateral haft element margin that show heavy grinding. This specimen cannot be assigned to a specific type with certainty, but it compares well with the contracting-stem Adena cluster defined by Justice (1987). Local types to which the specimen may be assigned include Gary or Category 7 (Kay 1980), Category CS2 (McMillan 1965), and Burkett Stemmed (Chapman 1980). All of these types are associated with Late Archaic to Woodland periods. The radiocarbon assay of 1670±70 B.P. from the same level in the adjacent Test Unit 2 supports a Middle Woodland age assessment for this specimen.

Finally, the artifact illustrated in Figure 36f is a straight-stemmed point with strong shoulders recovered from TU6, Level 3 (Stratum 1C context). The ears are rounded and the basal margin contains a portion of the cortex-covered platform of the original flake blank. This type of manufacturing technique is particularly common in Late and Terminal Archaic times. The specimen is typologically similar to Category SS4 or Verkamp points described by McMillan (1965); he assigns this point type to a Late Archaic-Late Woodland time range. The specimen is also similar to Delhi points, which Justice (1987) includes in a Terminal Archaic Barbed cluster. Recovery of a Late Archaic to Terminal Archaic point in the lowest level of Stratum 1 deposits is consistent with the presence of a Middle Woodland-age radiocarbon assay from the overlying level.

Lower analytical units in TU2/6 also produced points. Figure 37a illustrates the basal portion of a Graham Cave Side-notched point (Logan 1952; Justice 1987) recovered from TU6, Level 4 which exhibits the classic attributes of basal thinning, heavy grinding on the haft element and well-executed down-slanting side notches. Unfortunately this type is well-established as an Early Archaic point style, which implies that this specimen has been redeposited away from its original context of

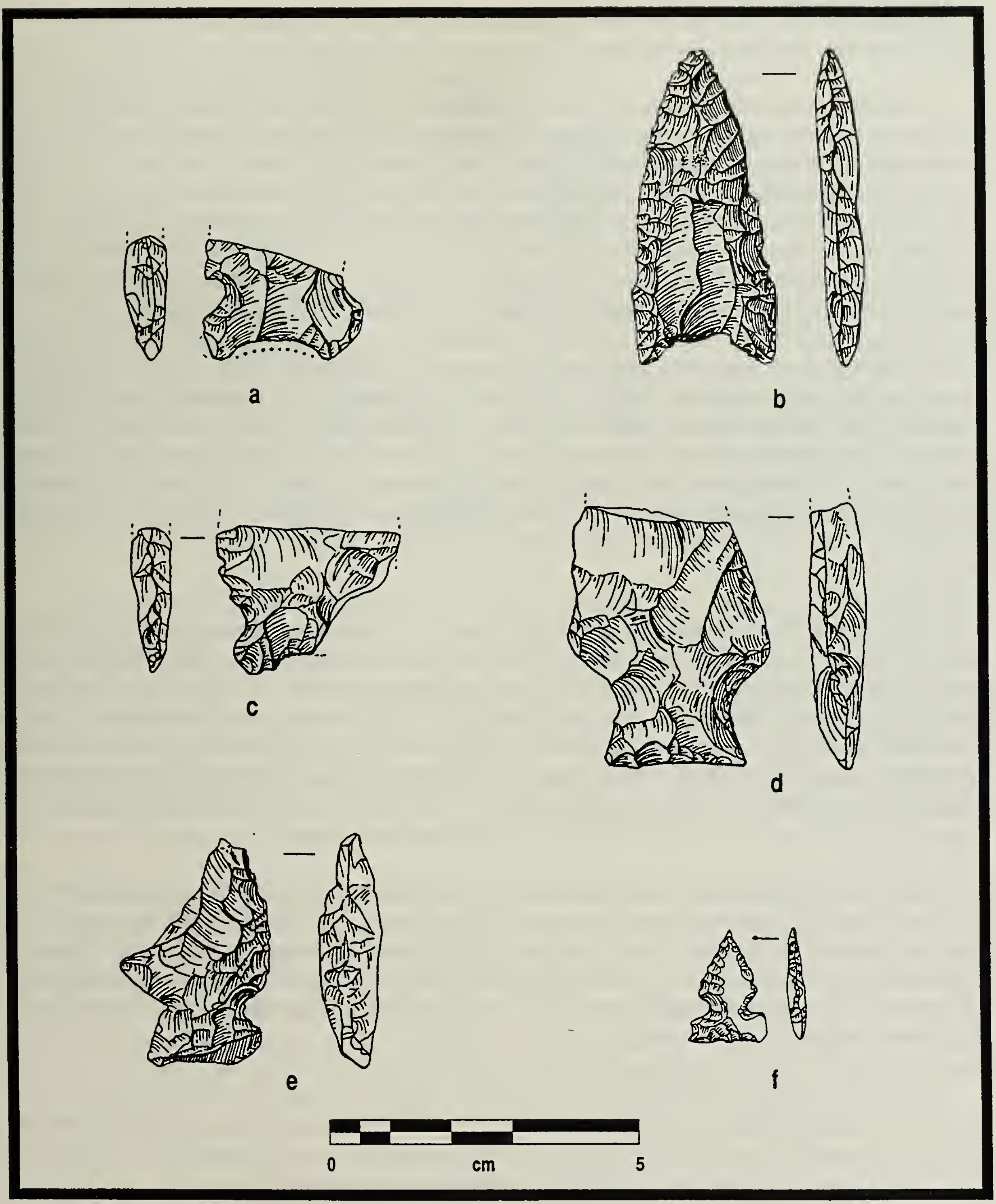


Figure 37. Temporally Diagnostic Projectile Points from Sadie's Cave: a, recycled Early Archaic Graham Cave Side-notched point (TU6/L4); b, recycled Dalton point (TU2/S3); c, Middle Archaic Large Side-notched cluster point (TU6/S3); d, Late Woodland Rice Side-notched point (TU3/S1); e, recycled large side-notch cluster point (TU3/S1); f, Late Prehistoric Reed Side-notched arrow point (TU3/S3 [Stratum 1?]).

manufacture and use. Bracketing radiocarbon assays indicate an age range between about 1,700 and 4,400 years ago for deposition of Level 4.

Another incidence of point recycling is evident from recovery of a Dalton point (Figure 37b) from Level 8 of Test Unit 2 (upper Stratum 3 context). The specimen is well-made and exhibits shallow fluting on one aspect and heavy grinding on the lateral haft element margins. This lanceolate point type is assigned to the transitional Paleoindian-Early Archaic time period; these points have been dated between 10,500 and 9,800 years ago in the mid-South region (Goodyear 1982). However, the radiocarbon assays of 6,760 and 6,520 years ago for TU2/Level 8 are much too young for the point to have been recovered from intact Dalton deposits. This specimen also represents a recycled projectile point that has been redeposited into a later stratigraphic context.

The specimen illustrated in Figure 37c is a basal fragment of a large side-notched point with a concave base recovered from TU6 Level 9 (middle of Stratum 3). This specimen may represent a fragment of a Middle Archaic Big Sandy point (Kneberg 1956). It can be assigned with some certainty to the Large Side-notch cluster (Justice 1987); most of the point types that compose this cluster were commonly manufactured during the Middle Archaic period. This typological assignment is consistent with the radiocarbon assays from TU2/Stratum 3 (6520 and 6760 B.P.) and the assays of 7450 and 7780 B.P. associated with the basal portion of Stratum 3 and the underlying Stratum 5 deposits.

Test Unit 3 produced three projectile points, all of which were recovered from Stratum 1 deposits. Level 1 produced two points. Figure 37d shows an expanding-stem or shallowly side-notched point that was probably broken medially during manufacture. There is light grinding on the lateral haft element margins and the base is straight. This specimen may be a variant of the Late Woodland Rice Side-notched type (Chapman 1980; McMillan 1965) which has more pronounced hafting because of the lack of resharpening. Kay (1980) illustrates some Rice Side-notched points that have some similar morphological attributes. The radiocarbon assay of 950 B.P. from this stratum supports the Late Woodland age assessment of the specimen.

Figure 37e illustrates a specimen that is morphologically similar to points in the Middle Archaic Large Side-notched cluster described above (Justice 1987). This particular specimen was recovered from TU3 Stratum 1 and is outside of its original context of manufacture and use. The specimen also shows evidence of recycling; at least four burination flakes have truncated segments of the distal, lateral, and basal margins. The point was probably picked up and reworked by Late Woodland inhabitants of the cave.

Finally, a small Late Woodland to Late Prehistoric arrow point was recovered from Test Unit 3, Level 3 context (Figure 37f). The exact location of the point is unknown, but field notes indicate that it was probably derived from Stratum 1 sediments in this mixed-stratum level. This specimen was made from a bifacially modified flake; portions of the original flake surface are still visible. This specimen is assigned to the Reed Side-notched point type (Bell 1958; Chapman 1980), a local name for one of many small side-notched arrow points made in the mid-South region during the Late Prehistoric period. This specimen is consistent with the radiocarbon assay of 950 B.P. associated with TU3 Stratum 1 deposits.

Test Unit 7 produced two projectile points. Level 1 (Stratum 1) produced a basal fragment of an unidentified corner-notched/expanding stem point (Figure 38a). This item is badly damaged from burning and also shows evidence of recycling. At least two burination flakes have been removed from the snapped distal margin, forming two chisel-like projections that show evidence of use. A temporal period is not assignable to this specimen due to the damage and its fragmentary condition, but it is similar to Category CN3 and Category CN6 points described by McMillan (1965). These types were both assigned to the Late Archaic to Late Woodland time range, which is consistent with recovery of this specimen from the uppermost stratum and level in the test unit.

The specimen illustrated in Figure 38b is assigned to either the Rice Lanceolate (Chapman 1975) or Rodgers Lanceolate (Kay 1980) types, both of which are Early Archaic in age. This specimen was heat-treated and is made from nonlocal (Burlington ?) chert. It has basal thinning and shows moderate grinding on the lateral and basal haft element margins. It was found at the interface between Stratum 3 and Stratum 4 deposits in Test Unit 7, and was probably deposited during one of the Early Archaic occupation episodes that resulted in reworking of some of the basal residuum deposits and deposition of low numbers of artifacts. This point is assumed to be in or near its original context of use and discard. Its presence is consistent with assignment of the reworked Stratum 4 and 5 deposits (and other morphologically and stratigraphically similar deposits) to an early Holocene time frame.

Finally, another possibly temporally diagnostic specimen was recovered from Stratum 1 deposits that were exposed during profile cleaning in the drainage depression/looter pit along the south wall of the cave. This artifact (Figure 38c) lacks a haft element, but the angled blade and corner-notch remnant suggest it may be assigned to the Late Archaic Afton Corner-notched type (Bell 1958; Chapman 1975). Recovery of a Late Archaic point from Stratum 1 contexts is somewhat problematic. This specimen may have been recycled and redeposited in the Stratum 1 sediment. Alternatively, its fragmentary condition may have produced an erroneous typological assignment. In any case, this particular specimen cannot be accorded much interpretive significance because of its questionable context and typological assignment.

The temporally diagnostic projectile points recovered at Sadie's Cave are generally consistent with the sequence of associated radiocarbon assays. However, there are at least four and possibly six instances of recycling of early projectile point forms and incorporation of these specimens into later sedimentary contexts. The relatively high incidence of tool recycling is not particularly troubling, because the overall low sedimentation rates within the shelter would not have resulted in rapid burial of the remains of previous occupations. The recycled specimens may very well have been at or very near the ground surface and if so, would have been easily accessible to later inhabitants of the cave.

Radiocarbon Chronology

Test units 4/5 and 2/6 provided the deepest stratigraphic sequences observed at the site, with the Holocene depositional sequence represented by up to 1.6 m of deposition. Test units 3 and 7 also contained what appeared to be a complete stratigraphic sequence, but the Holocene time span is compressed in these units into only 50–60 cm of sediment. Attention therefore focused on the deeper stratigraphic sequence, which should provide finer chronological control. Supplementary samples also were taken from test units 3 and 7 to provide more complete temporal control and

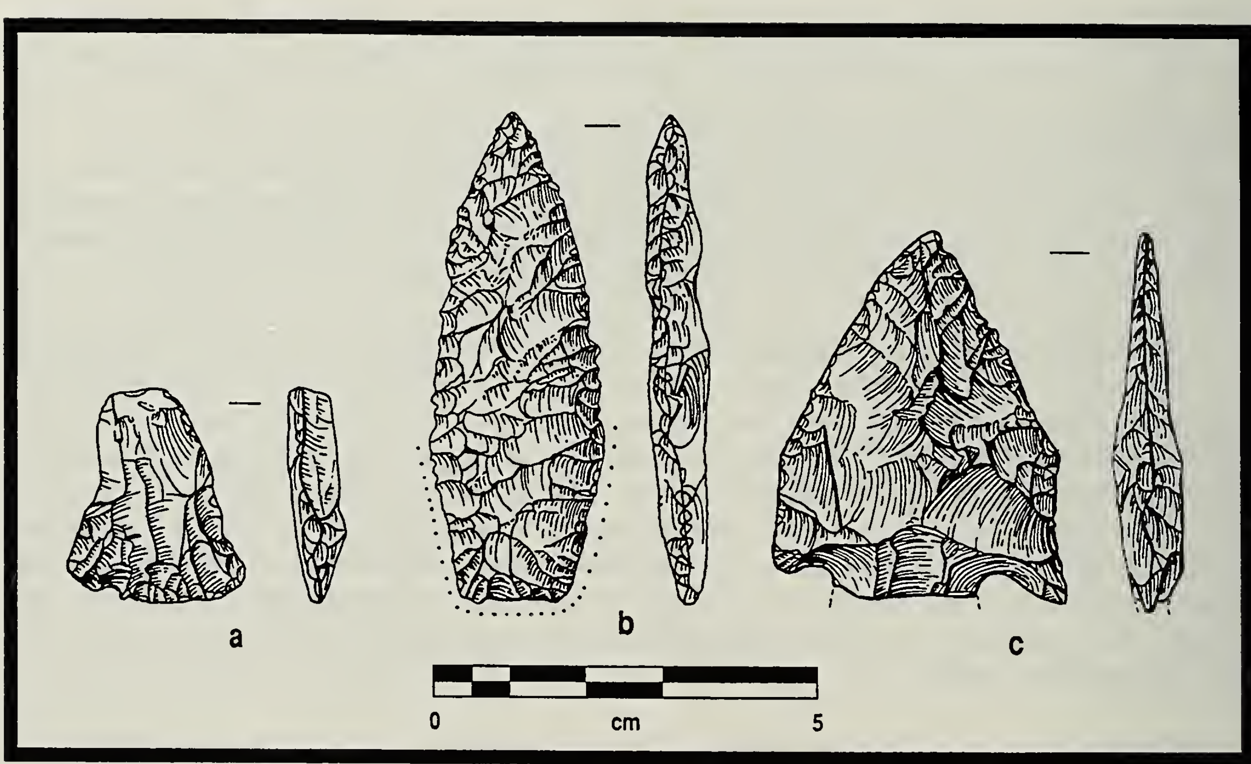


Figure 38. Temporally Diagnostic Projectile Points from Sadie's Cave. a) recycled unidentified corner-notched/expanding stem fragment (TU7/S1); b) Early Archaic Rice Lanceolate point (TU7/S4); c) possible Late Archaic Afton Corner-notched point (drainage depression profile, Stratum 1).

investigate possible time-transgressive lateral accumulation or redeposition of sediment on the aggrading Holocene sediment cone.

Unless otherwise noted, all samples were assayed by Beta Analytic, Inc. Samples were given standard acid-alkali-acid pretreatment which reduced the original sample masses by between 40 and 60 percent. This reduction in sample mass resulted in application of extended counting time for selected samples. Because of the desire to build general comparative Holocene chronological sequences for each test unit, the greater assay precision afforded by extended counting time was not considered necessary for many of the low-mass samples. Table 10 presents the results of the assays. Samples with low mass, those that received extended counting time and those assayed by AMS technique are noted.

Test Unit 4/5. A series of five samples was submitted from Test Unit 5 contexts, providing dates for deposition of strata 1, 2A, 2B, 3–5, and 7. Based on recovery of ceramic artifacts from strata 1 and 2A, radiocarbon assays of less than 2,000 years age were expected. These expectations were realized. The Stratum 1 sample apparently represents occupation of the site during late Late Woodland times, and is consistent with recovery of Meramec ware ceramics from this context. The samples from Stratum 2A and Feature 8 (bottom of Stratum 2B) represent a minor reversal in the

Table 10. Radiocarbon Assays from Sadie's Cave and Calendrical Calibrations.

Laboratory Number	Provenience	Material	Date (RCYB.P.)	One-sigma Calendrical Calibration
Test Unit 4/5				
Beta-79714	TU5/Level 1, Stratum 1	Wood/nutshell	950±60	A.D. 1020 (1040) 1175
Beta-79715	TU5/Level 3, Stratum 2A	Wood/nutshell	1460±50	A.D. 575 (620) 650
Beta-79719	TU5/Feature 8, Stratum 2B	Oak bark	1430±50	A.D. 605 (640) 660
Beta-79720	TU5/Feature 9 and Level 9, Stratum 3–5	Nutshell/wood	3800±90[b]	2400 (2200) 2040 B.C.
Beta-79722	TU5/Level 12, Stratum 7	Wood/nutshell	5460±200[a]	4485 (4330) 4045 B.C.
Test Unit 2/6				
Beta-78609	TU2/Level 2, Stratum 1B	Wood/nutshell	1670±70	A.D. 260 (410) 440
Beta-79723	TU6/Level 5, Stratum 2	Wood/nutshell	4390±120[a]	3310 (3015,2985,2935) 2895 B.C.
CAMS-7299	TU2/Level 8, Stratum 3	Humic extract	6520±70[c]	5480 (5440) 5340 B.C.
CAMS-7480	TU2/Level 8, Stratum 3	Carbon extract	6760±80[c]	5680 (5600) 5530 B.C.
CAMS-7481	TU2/Feature 2, Stratum 3	Carbon extract	7780±70[c]	6620 (6550) 6470 B.C.
CAMS-7482	TU2/Feature 2, Stratum 3	Carbon extract	7780±70[c]	6620 (6550) 6470 B.C.
Beta-79717	TU2/Level 14, Stratum 5	Wood/nutshell	7450±180[a]	6435 (6225) 6055 B.C.
Test Unit 3				
Beta-79716	Level 4, Stratum 2	Nutshell/wood	4970±90	3925 (3760) 3660 B.C.
Beta-79718	Level 6, Stratum 3	Nutshell/wood	5080±200[a]	4070 (3935,3860,3820) 3660 B.C.
Test Unit 7				
Beta-79721	Level 1, Stratum 1	Wood/nutshell	950±70	A.D. 1015 (1040) 1180
Beta-79724	Level 2, Stratum 2	Nutshell/wood	4150±90	2885 (2860,2815,2680) 2580 B.C.
Beta-7925	Level 3, Stratum 3	Wood/nutshell	4210±80	2900 (2875) 2630 B.C.

[a] Denotes a low-mass sample that did not receive extended counting time
[b] Denotes a low-mass sample that was subjected to extended counting time
[c] Denotes a very low-mass sample assayed by AMS technique

depositional sequence. However, the assays are of very similar age and overlap strongly at the one-sigma range. Both of the strata were apparently deposited during the early part of the Late Woodland period; the similarity in the sample ages indicates that materials from these substrata can be grouped into a general TU5/S2 analytical unit. The fourth assay in the series was derived from carbon taken from Feature 9 and the general sediment matrix with which Feature 9 was associated (Level 9); both proveniences represent Stratum 3–5 contexts. This sample was expected to date to the late part of the Middle Archaic period, based on intuition and possible comparison with the stratigraphic sequence in Test Unit 2/6. The assay of 3800 B.P. is considerably later than expected, but is consistent with the overall sequence in the test unit and recovery of a probable Late archaic projectile point from the same level. The lowest sample in the sequence was derived from the upper level of Stratum 7 deposits. Again, the assay of 5460 B.P. is much later than our expected date of 7000–8000 B.P. (early Middle Archaic), but the assay is consistent with the stratigraphic sequence and will be accepted. No sample was submitted from Stratum 8 contexts (reworked basal residuum).

The Test Unit 4/5 assays indicate that the Holocene stratigraphic sequence in this part of the site accumulated during the past 5,500 years or so. This finding suggests that Holocene sediment accumulation did not begin until the latter part of the Middle Archaic period. Perhaps this sediment accumulation was initiated in response to late Hypsithermal alterations of the local vegetation or landscape.

Test Unit 2/6. Three samples derived from Test Unit 2 contexts were submitted for assay as part of the 1993 Phase II testing. These sample produced a total of five assays because two samples were split and the fractions assayed separately. Two additional samples were submitted from the 1994 excavations to fill some of the gaps in the chronostratigraphic sequence. Seven assays are available from Test Unit 2/6 contexts.

The uppermost sample was composed of flotation and hand-picked samples taken from Stratum 1B (Level 2). It was expected that this sample would date between 500 and 4,000 years ago, based on recovery of Late Woodland sherds from the cave surface and a Late Archaic projectile point from the Stratum 1 in the exposed drainage depression/looter pit profile. The sample assayed to 1670±70 B.P., which suggests that Test Unit 2/6 Stratum 1 is generally contemporary with strata 2A and 2B in Test Unit 4/5. An early Late Woodland cultural affiliation is indicated, which is consistent with recovery of Meramec ware sherds.

The second sample of the series was extracted from the general sediment matrix of TU6/Level 5, located near the top of Stratum 2. This sample assayed to 4390 B.P., which is intermediate between the dates from strata 3-5 and 7 in Test Unit 5. Deposition of Stratum 2 during the Late Archaic period is indicated. In 1993, two samples were sent for accelerator mass spectrometry (AMS) assay to Lawrence Livermore National Laboratories. One sample was taken from Level 8 at the top of Stratum 3 deposits. The Level 8 sample was submitted because of the recovery of a Dalton projectile point from this level (see discussion below). If the Dalton point was in its primary depositional context, a radiocarbon sample from the associated level should assay in the range of 9,500 to 10,500 years ago (see Goodyear 1982). This sample was divided into two fractions at the laboratory (CAMS). The first fraction consisted of humic acids extracted from the wood charcoal and surrounding matrix. The assay for this fraction is 6520±70 B.P. (CAMS-7299). Assay of the carbonized material itself produced a date of 6760±80 B.P. (CAMS-7480). Neither of these dates indicate Dalton age for the upper portion of Stratum 3. The Dalton point was

apparently recycled prehistorically and represents secondary deposition in Level 8 contexts. The assays indicate that Stratum 3 was probably deposited during the mid-Holocene.

The other 1993 sample was a single large fragment of wood charcoal recovered adjacent to the right tibia exposed in Feature 2 (associated with the deposition of the lower part of Stratum 3). Assay of this sample was expected to provide an estimated date for interment of the burial and deposition of the lower Stratum 3 sediments. This sample was also split into two fractions at CAMS. Both fractions assayed to 7780±70 B.P. (CAMS-7481 and CAMS-7482) indicate that the Feature 2 burial and probably the lower portion of Stratum 3 were deposited during the early part of the Middle Archaic period. Stratum 3 apparently accumulated between about 7,800 and 6,500 years ago, during the Middle Archaic period.

To provide a more complete chronostratigraphic sequence, a sample was submitted from Stratum 5 contexts below the level of the Feature 2 burial. This lowest sample in the series was expected to date to the Early Archaic period, during which it was expected that the basal residuum sediments had been reworked to create the lower stratigraphic series in each test unit. The sample produced an assay of 7450±180 B.P., which represents a minor reversal in age compared to the Feature 2 assays. However, the large standard deviation associated with the lower sample overlaps the Feature 2 assay at the two-sigma range. This finding suggests that the Stratum 5 deposits were aggrading rapidly during the early part of the Middle Archaic period, and that Feature 2 and the underlying Stratum 5 sediments are nearly contemporary.

The overall chronological range for Test Unit 2/6 is greater than that of Test Unit 4/5, but the general sequence is similar. The TU2/6 assays again indicate sediment aggradation during the middle and late Holocene. The early Holocene surface in the cave was apparently not a depositional environment.

Test Unit 3. Two samples were submitted from Test Unit 3 for assay. Stratum 1 was left undated in this sequence, but samples from strata 2 and 3 contexts were assayed. The sample derived from Stratum 2 (Level 4) context was expected to date to date to the Late Archaic period and the Stratum 3 (Level 6) sample was expected to date to the Middle Archaic period. The assays are in concert with their stratigraphic position of the samples, but the expected assays were not produced. The assays instead indicate that both strata 2 and 3 are of similar age and can be assigned to the Middle to Late Archaic boundary. Strata 2 and 3 appear to be generally contemporary with Test Unit 4/5 Stratum 3-5 and Test Unit 2/6 Stratum 2 sediments.

Test Unit 7. Three samples were submitted for assay from Test Unit 7. One sample was taken from each of the upper three levels in this test unit; these samples are associated with the upper three strata in the sequence. It was expected that the Stratum 1/Level 1 sample would date to the Late Woodland period; several Meramec ware sherds had been recovered from this level. Strata 2 and 3 were again expected to date to the Late and Middle Archaic periods, respectively, and were further expected to be generally contemporary with the corresponding strata exposed in Test Unit 3.

The Stratum 1 sample yielded an assay of 950±70 B.P., a date almost identical to the TU5 Level 1 assay. This date confirms the Late Woodland cultural affiliation of this uppermost stratum. The Stratum 2 and Stratum 3 samples proved to be much younger than anticipated. The assays of

4150±90 and 4210±80 from these strata are congruent with their relative stratigraphic positions. These assays also indicate that both strata are generally contemporary and were deposited during the Late Archaic period. These assays postdate the dates on strata 2 and 3 in Test Unit 3, suggesting slow lateral and vertical aggradation of sediments on the footslope of the Holocene sediment cone.

Summary and Implications. The suite of radiocarbon assays available from Sadie's Cave permits several aspects of site chronology to be addressed. Of primary importance in this array of dates is the fact that with two minor exceptions, all of the dates from each test unit are congruent with the stratigraphic position of the samples. Successively younger deposits are higher in the profile column. Exceptions to this trend are the minor chronological reversals represented by the TU2/6 Feature 2 and Stratum 5 assays and the TU4/5 strata 2A and 2B assays. In both instances there is a reversal of the trend in centroid dates, but when the standard deviations are considered as well, the assays in each pair are not statistically different (Stuiver and Reimer 1993). Other sample pairs from the same test unit sequence that show no statistically differences are the strata 2 and 3 samples from Test Unit 3 and the strata 2 and 3 samples from Test Unit 7.

Second, the cultural deposits with the lowest elevations (TU2, strata 3 and 5) have the oldest dates. This suggests that the low area around the drainage depression near the south cave wall was being infilled earlier than sediment was accumulating on the surrounding ground surface. Infilling and accumulation of Holocene colluvial sediments began early in the Middle Archaic period, and may well have coincided with the onset of the Hypsithermal climatic interval around 8,500 to 8,000 years ago. The infilling in the lower areas within the cave may have resulted from both natural and cultural depositional processes.

Third, the underlying reworked basal residuum sediments may contain occasional evidence of older occupations, but these remain undated due to the low incidence of carbon in these sediments. AMS dating of the small samples is possible, but was not attempted here due to the high cost of these kinds of assays. In addition, an AMS assay is probably unnecessary for these deposits. A general Early Archaic time period can be assigned to these upper, reworked residuum deposits because of the recovery of the Rice Lanceolate point from the top of these sediments in Test Unit 7 and because all of the overlying sediments are assigned to Middle Archaic or later time periods.

Fourth, all of the strata overlying the reworked basal residuum in all test units was deposited during the Holocene. Deposition of sediment through accumulation of a colluvial sediment cone began near the beginning of the Middle Archaic period (7,500–8,000 years ago) and continued gradually throughout the Holocene. By the end of the Middle Archaic period (about 5,000 years ago), sediment had accumulated over about half the area now occupied by the colluvial cone; TU5/Stratum 7 and TU2/6 Stratum 3 were deposited during this time span. The major period of sedimentation occurred during the Late Archaic period between about 5,000 and 3,500 years ago. During this time, TU4/5 Stratum 3–5, TU2/5 Stratum 2, TU3 strata 2 and 3, and TU7 strata 2 and 3 were deposited. There is an apparent gap of about 2,000 years in the radiocarbon ages; no samples yielded dates in the 3800 to 1700 B.P. time span. The absence of dates for this time span may indicate a hiatus in sedimentation within the late Holocene period. Lastly, the strata 1–2B in Test Unit 4/5 and Stratum 1 in the other test units were deposited in the last 1,700 years. All test units show evidence of occupation during the Late Woodland period, and at least two distinct episodes of site use are indicated. Three assays cluster in the 1700 to 1400 B.P. time range, and two other assays indicate occupation around 950 B.P.

Fifth, the relatively long spans of time assigned to all major strata and the relatively low sedimentation rates present within the cave reinforce our earlier interpretation that all of the Holocene strata contain the remains of multiple episodes of human occupation. None of the strata were deposited as a result of intense, long-term human occupation, and none of the strata represent short-term natural depositional events. Individual occupation surfaces will be difficult if not impossible to define. Later analyses of specific data sets should make maximum use of fact that there are good stratigraphically controlled assemblages from all test units that can be linked to major temporal periods. The analyses will therefore focus on recognition of long-term temporal trends that can be extracted from analysis of materials from one or more of the test unit sequences.

Finally, there is evidence for time-transgressive accumulation of sediments laterally within the cave. The sediments immediately overlying reworked residuum produced dates of 5460 B.P. in Test Unit 2 (at the apex of the sediment cone near the cave mouth), while sediments in the same relative position dated to 5080 B.P. in the Test Unit 3 area and to only 4210 B.P. near the footslope of the sediment cone (Test Unit 7). This time range spans the Middle-Late Archaic boundary and includes occupations that took place both during and after the Hypsithermal. This finding indicates that the relative position of strata within the columns cannot be the sole basis for constructing time-stratigraphic units within the Sadie's Cave deposits. The radiocarbon assays themselves must be the primary means of correlating stratigraphic sequences among units.

Interunit Stratigraphic Correlations

Six interunit correlated stratigraphic units can be defined at Sadie's Cave, based on 1) radiocarbon assays associated with specific strata that can be grouped into general temporal ranges; 2) similarities in texture, structure, color, and inclusions observed in the major strata of all test units; and 3) recovery of temporally diagnostic artifacts in association with some strata. These time-stratigraphic units, referred to henceforth as Strata Sets, are given letter designations A through F. The constituent analytical units for each Strata Set are listed in Table 11, and the schematic relationships among analytical units, test units and strata sets is shown in Figure 39. All Sadie's Cave analysts were provided with copies of this information and their analyses included examination of data by Analytical Unit (keeping both test units and strata separate) and by Strata Set (allowing combination of selected strata across test units). These two approaches permitted examination of both localized remains of human occupations and broader comparisons long-term trends in the data.

In constructing the analytical elements of the strata sets, the surface analytical unit was kept separate, as were several analytical units that represent mixed stratigraphic contexts. However, several of these mixed analytical units represent samples of the interface between Strata Sets A and B. These samples are often presented as a separate strata set (A/B) grouping. This mixed strata set group proved to be particularly informative, given that there may have been a hiatus in sedimentation between accumulation of Strata Set B and Strata Set A sediments. During this time of potential nondeposition, repeated human occupation may have occurred on the stable cave surface. Surface features are often included in the appropriate Strata Set with which they are depositionally associated. However, due to the high variability in density of specific material classes taken from feature contexts, the analytical units representing individual features were excluded from the strata sets. The effects of special-function contexts (features) on analyses is particularly evident in the case of the larger intrusive pit features such as Feature 2, which included numerous modified items as grave

Table 11. Constituent Elements of the Strata Sets Used in Sadie's Cave Analyses.

Strata Set	Constituent Analytical Units			
	TU 2/6	**TU 3**	**TU 4/5**	**TU 7**
A	TU2/S1	TU3/S1	TU5/S1	TU7/S1
	TU2/F112	TU3/F4	TU5/S2	
			TU5/S2A	
			TU5/S2B	
			TU5/L4	
			TU5/F6	
			TU5/F8	
B	TU2/S2	TU3/S2	TU5/S3	TU7/S3
	TU2/F104	TU3/S3	TU5/S5	
		TU3/F109	TU5/S3–5	
		TU3/F5	TU5/F9	
C	TU2/S3		TU5/S7	
D	TU2/S5			
E	TU2/S7	TU3/L7	TU5/S8	TU7/S4
			TU5/F119	TU7/S5
F	TU2/S6			

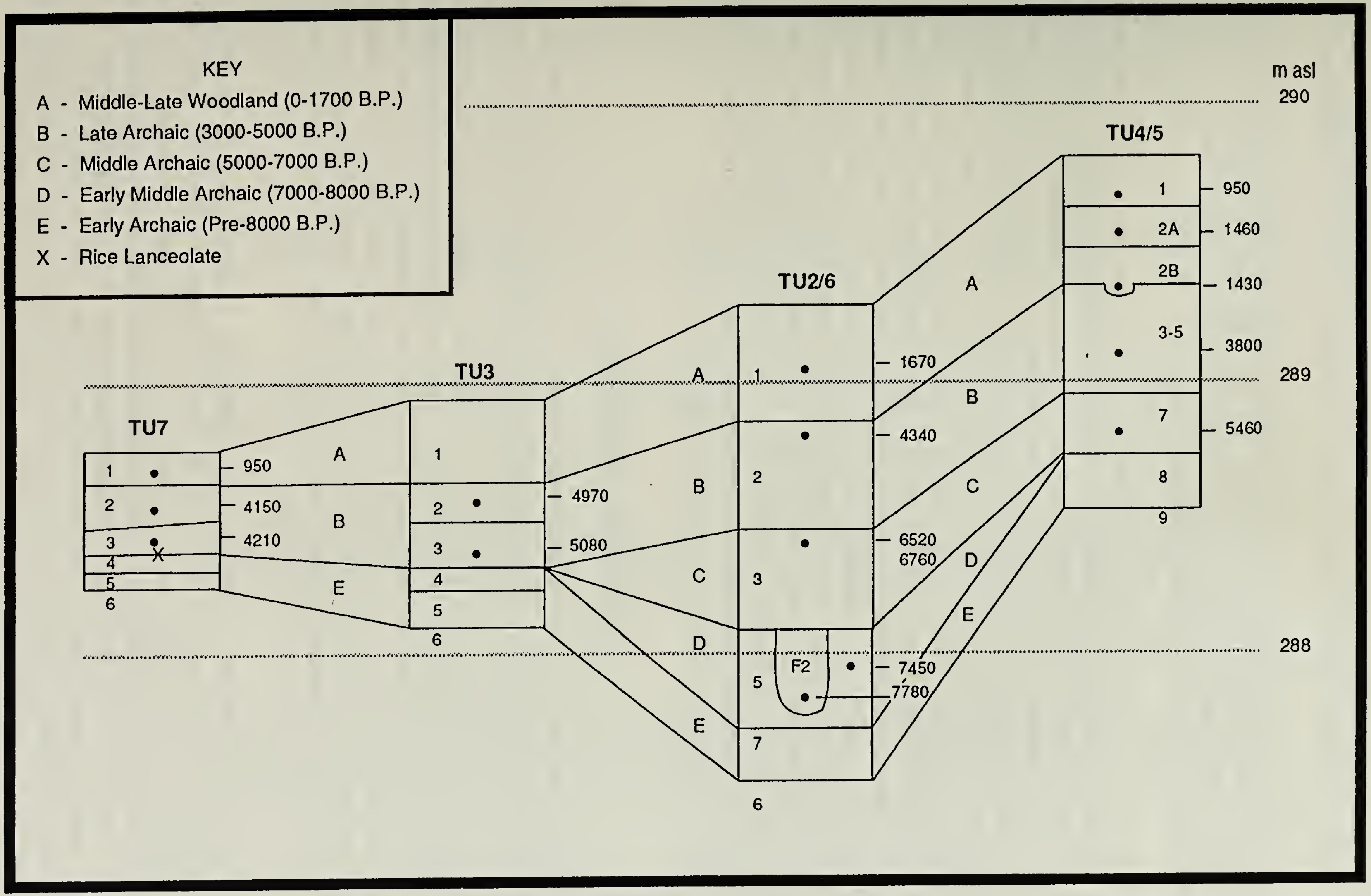


Figure 39. Schematic Drawing of Sadie's Cave Test Units, Major Strata and Strata Sets. Radiocarbon assays are located with dots, and the associated centroid date is listed.

goods. The pit features with high densities of specific material classes (Features 2, 3, 8, and 101) have been retained as separate analytical units throughout the analyses (see also Tables 4 and 7).

Analytical units that stand alone and are not assigned to strata sets include surface materials; TU2/F2 (associated with Strata Set D); TU3/L3, TU7/L2, TU2/L4, and TU5/L6 (all of which are associated with the A/B interface); TU5/F101 (Strata Set A); TU5/F3 (Strata Set B), TU5/L11 (Strata Set B/C interface), and TU1/S1 (not assigned).

Strata Set A includes all of the Late Woodland occupations of the site, and other occupations that may be included in the uppermost dark, ashy strata in each test unit sequence. Strata Set B includes the next lowest strata and all of those that were deposited between about 3,800 and 5,000 years ago. This strata set essentially includes all of the Late Archaic occupation episodes contained within the site. Both Strata Sets A and B are represented in all test units. Strata Set C includes those strata deposited during the Middle Archaic period (5,000 to 7,000 years ago), during which time any effects of the Hypsithermal climatic changes would probably have their best expression. Strata Set C is represented only in test units 2/6 and 4/5. Strata Set D represents the period of early infilling of the drainage depression and is only expressed in the Test Unit 2/6 sequence (Stratum 5). The Feature 2 burial is generally contemporary with this strata set, but is not included because of the special function of the feature and highly skewed nature of its assemblage (grave goods). Strata Set E includes those strata that have been interpreted as representing basal residuum sediments that were reworked and culturally augmented during the Early Archaic/early Holocene period. These sediments occur in all test units. Strata Set F is represented by the in situ basal residuum, and was sampled in only one location, a flotation sample from Stratum 6, Test Unit 2.

Trends in Major Material Classes

To obtain a general impression of the relative intensity of frequency of human occupation within each analytical unit and strata set, the overall frequency distribution of the major material classes (bone, shell, lithic artifacts, and rough rock) was calculated. The impression in the field was that the Late Woodland strata in each test unit had the highest frequency of artifacts, but this impression needed to be confirmed using actual data. Because the excavated volumes of each stratum were not similar, comparisons among analytical units were standardized as density values. Weights (g) or counts (n) of major material classes per excavated unit volume (liters) were calculated for each analytical unit and these were graphed for to compare individual strata within each test unit. These graphs also served to identify analytical units with particularly high or low density values relative to their correlated strata in other test units.

If sediment deposition rates are relatively constant through time, variation in the amount or density of major material classes is assumed to result from changes in the frequency and duration of human occupation or from changes in the range or types of activities performed at the site. Examination of the relative contribution of material classes to the sediment matrix should help identify major changes in site function by distinguishing changes in the relative contribution of selected major material classes to the accumulating sediment matrix. Only materials from general excavation levels are included, since flotation recovery was screened through finer mesh and also represents lower sample volumes. Density data in Table 12 include calculations of either weight or

Table 12. Density and Volume Data for Selected Major Material Classes Recovered from Sadie's Cave.

Analytical Unit	Volume	Lithic Density (g/liter)	Bone Density (g/liter)	Shell Density (g/liter)	Rock Density (kg/liter)
TU1/S1-4	285	0.046	>0.001	0.027	---
TU5/S1	125	1.128	0.065	0.297	0.210
TU5/S2	396	0.465	0.164	0.152	0.020
TU5/L4	96	0.396	0.140	0.649	0.067
TU5/S3-5	506	0.534	0.358	0.212	0.146
TU5/L11	55	0.655	0.204	0.227	0.615
TU5/S7	215	0.340	0.158	0.091	0.463
TU5/S8	189	0.032	0.009	0.001	1.328
TU5/F3	2	12.500	8.150	1.300	0
TU5/F6	5	0	0.540	0	0.100
TU5/F9	9	0.333	0	0	0
TU5/F101	17	0.824	0	0.265	0.029
TU2/S1	557	1.296	0.153	0.482	0.091
TU2/L4	160	1.763	0.167	0.214	0.088
TU2/S2	421	0.534	0.079	0.150	0.225
TU2/S3	471	0.518	0.168	0.131	0.336
TU2/S5	229	0.201	0.043	0.031	0.253
TU2/S7	20	0	0	0	0.925
TU2/F2	184	0.946	1.623	0.211	0.574
TU3/S1	175	0.651	0.151	0.911	0.146
TU3/L3	85	0.282	0	0.151	0.412
TU3/S2	170	0.382	0.153	0.295	0.506
TU3/S3	85	0.353	0.028	0.022	0.753
TU3/L7	120	0.167	0	0.001	0.750
TU7/S1	91	0.670	0.320	0.564	0.181
TU7/L2	85	1.047	0.244	0.279	0.196
TU7/S3	62	0.613	0.276	0.458	0.361
TU7/S4	20	0.400	0.020	0	1.125
TU7/S5	23	0	0	0	1.217

Note: Data are arranged by analytical unit within test unit.

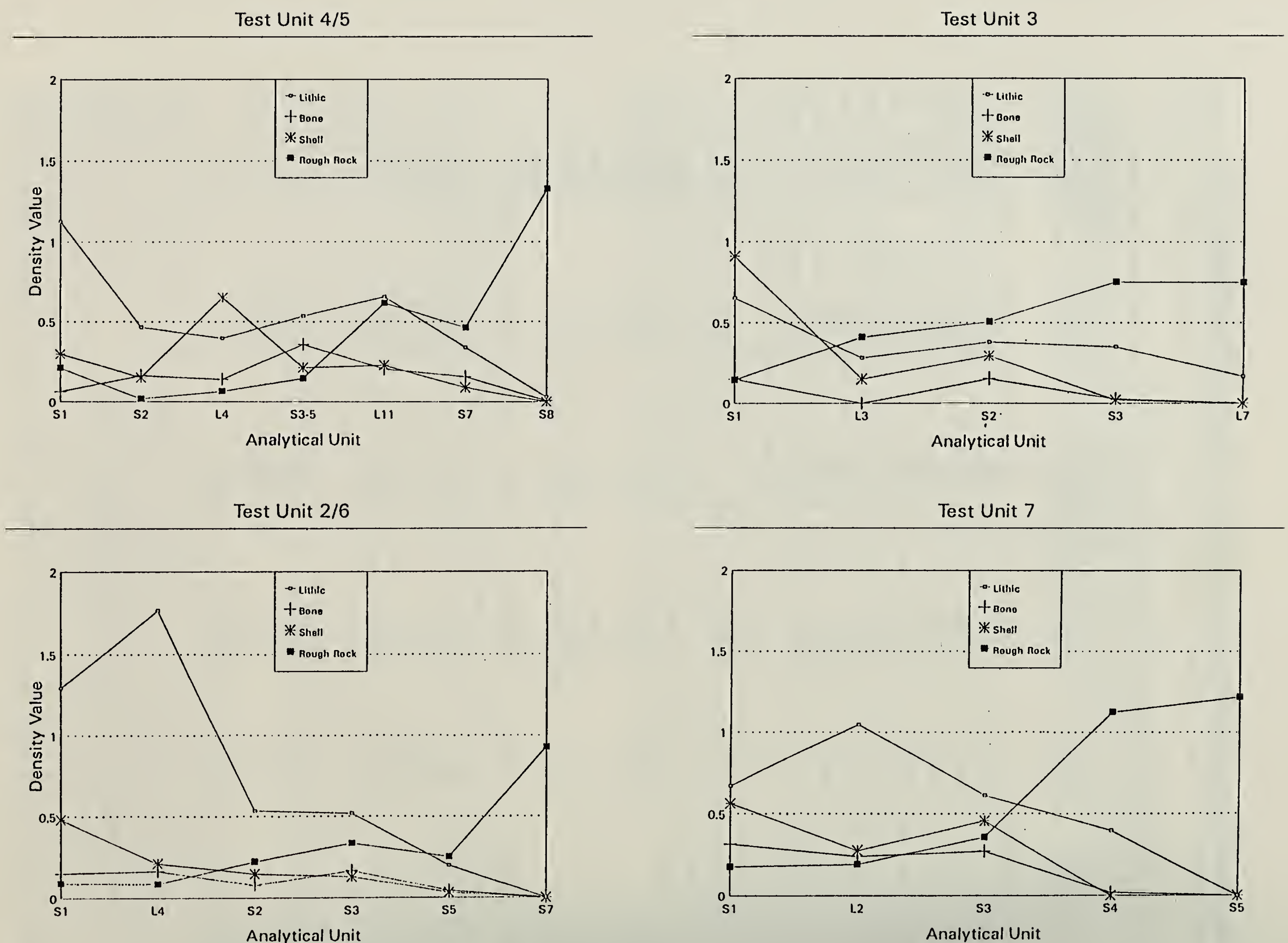


Figure 40. Graphs of Density Values of Selected Major Material Classes for Each Test Unit at Sadie's Cave. Test Unit 1 and the feature-based analytical untis are omitted.

frequency densities, depending on the material class. Densities of lithic artifacts are based on frequencies of debitage only, which compensates for the effects of a few large items with high mass, such as ground-stone artifacts or cores. Densities of shell and bone are based on mass to compensate for the potential of increased counts due to breakage. Rough rock density is based on the weight of rocks >5 cm in any dimension; these items were examined in the field for evidence of use, weighed for each level and discarded. Figure 40 illustrates the trends in material class densities, using the analytical unit totals from Table 12.

The density data presented in Table 12 show highly variable values for the features. This variability is due in part to low sample volumes and due in part to the variability of feature contents, especially those features that may have been used for specific short-term tasks. In general, features will be excluded from the following discussions because these highly variable density values make them uninterpretable. Features have been omitted from the graphs for each test unit shown in Figure 40.

Examination of the data presented in Table 12 and Figure 40 reveals some trends that are expressed consistently in all test unit sequences. One trend is that the density of rough rock generally increases with depth in all test units. Rough rock density is fairly low in the upper strata, but there is often an increase in the analytical unit that immediately overlies the reworked residuum sediments, followed by an even larger increase in the basal stratum. This trend indicates that the basal stratum was highly enriched with naturally occurring rock derived from periodic roof fall and other weathering processes. The amount of rock in the sediment is much lower in the Holocene strata, and this may be due to changes in water flow and related weathering regimes within the cave.

If the density of a specific cultural material class shows a marked change relative to the densities of the other material classes, this may indicate a shift in site function or variation in the types and range of activities performed during deposition of that analytical unit. On the other hand, density changes that affect all cultural material classes proportionately are interpreted as changes in the overall frequency or duration of human occupation. The graphs in Figure 40 show a general increase in cultural material classes through time, indicating that the frequency or duration of human occupation generally increased throughout the Holocene. To further accentuate general changes in material class density through time, density values were calculated using the combined strata sets to represent broad temporal/depositional units. The resulting data are graphed on Figure 41.

However, there is considerable variability in the proportions of specific material classes through time. For example, density of lithic debitage shows a steady increase through time, but exhibits a more pronounced density peak in either the uppermost stratum or in the next lowest analytical unit that contains mixed Stratum 1 and Stratum 2 deposits. These increases in lithic debitage counts are disproportionately larger than the changes in other cultural material classes. This finding suggests that during the latest occupations of the cave, there was an increase in use, manufacture or discard of lithic materials, which possibly heralds a shift in the overall site function or in the range of activities performed during the Woodland period occupation of the site. Another evident trend in all test unit sequences except for TU4/5 is that density values for mussel shell also show disproportionate increases in the upper analytical unit. Shell also appears to increase in density toward the back of the cave. This pattern may be due to differential discard of materials within the cave as well as an overall increase in the use of mussel shell during the Woodland period.

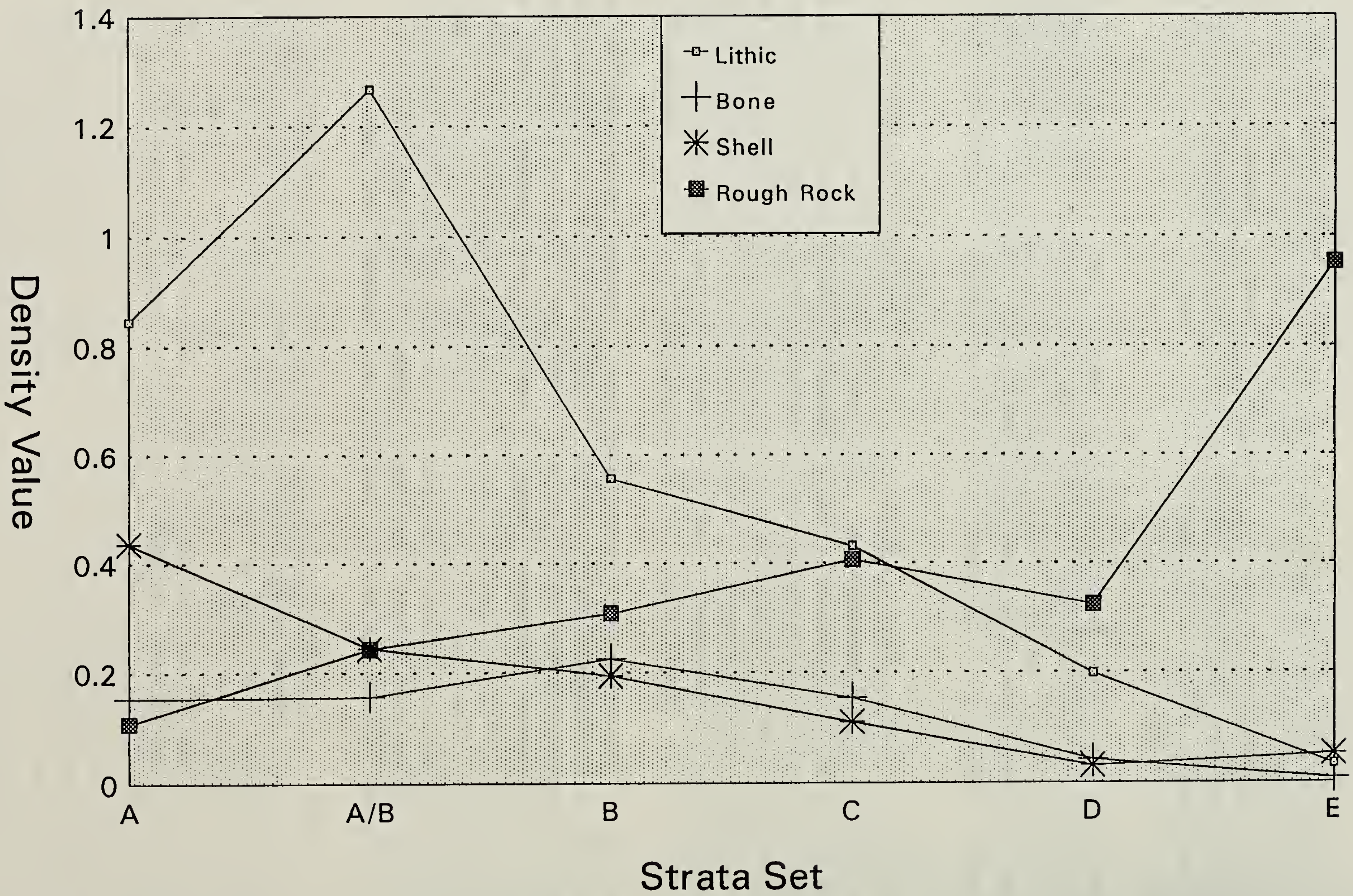


Figure 41. Density Values of Selected Major Material Classes for Sadie's Cave Strata Sets.

Finally, the peak in shell density in the TU5/L4 analytical unit and the peaks in lithic density that occur in the TU2/L4 and TU7/L2 analytical units may indicate accumulation of discarded cultural materials on a surface that was relatively stable for 1,500 to 2,000 years. Alternatively, these high-density values may be indicative of the spatial location of specific activity or discard areas that were in use during this period of time. In either case, the fact that these analytical units have unique material class density signatures compared to other analytical units indicates that these stratigraphically mixed levels should be combined and treated as a separate strata set that includes materials derived from the Strata Set A/B interface.

Figure 41 shows the overall changes in material class density values calculated for the strata sets. This graph clearly validates several of the observations made above. There is an overall increase in the density of all major material classes through time. However, Strata Sets A and A/B show major increases in the density of lithics debitage that is disproportionately high. Shell density also increases markedly in Strata Set A, while the bone density values actually show a slight decrease in the latter strata sets.

Three tentative conclusions can be drawn from these trends, which can in turn be treated as hypotheses to be tested through detailed analyses of specific data sets. First, there is an overall increase in the intensity (frequency or duration) of human occupation through time, with highest rates of accumulation of cultural material associated with the Woodland occupations included in Strata Set A. Second, during this same time period, there are changes in the relative proportions of lithic, bone and shell material classes that indicate that the function of the site in the local settlement system may have changed during this later time period. At the very least these changes indicate that the range and types of activities performed during the Woodland period were both quantitatively and qualitatively different from the activities performed during earlier time periods. Third, there is no evidence that the Hypsithermal Interval affected human use of the cave either positively or negatively. The Middle Archaic strata sets (C and D) show no peaks in any cultural material class that could be interpreted as an increase in the frequency or duration of site use. If the Hypsithermal affected the local environment of Sadie's Cave, it was in a more subtle manner that did not result in major changes in occupational intensity.

To explore this last inference more fully, more detailed information is needed on the effects of the Hypsithermal Interval on local environmental conditions. Analyses of terrestrial gastropods and mussel shells as paleoenvironmental indicators provide a more complete understanding of the middle Holocene environment, and also provide a baseline context for examining other possible changes in human use of the site during this time span. These paleoenvironmental analyses are presented in the next sections.

Analysis of Terrestrial Gastropods

The remains of invertebrate and vertebrate animals recovered from archaeological contexts are now commonly used as proxy indicators of past environments, climates and human subsistence patterns. Among the invertebrates, mollusks—particularly terrestrial gastropod (snail) shells—are abundant in many Holocene deposits. The majority of these shells are specifically identifiable on the basis of their shell morphology and are referable to living species. The use of snail shells as indicators of past environmental conditions requires a knowledge of the factors that today influence

the distribution of particular species. An assumption is made that the habitat preferences and limiting factors of a species have remained consistent through time, so that past environmental conditions as reconstructed from subfossil assemblages are based upon our knowledge of the requirements of an identical living taxon. This "constancy of habitat principle" is applied to molluscan faunas; "It seems reasonable to assume that a species living in a given environment now must have preferred the same environment in the past" (La Rocque 1966:17). Or in other words, an assumption is made "that species have been influenced in former periods by the same limiting factors and to the same degree as they are now" (Taylor 1960:4). However, few gastropod taxa have been studied in detail and precise data on the edaphic and climatic parameters for many species are of little value in the extant literature, if not erroneous. Unfortunately, even less information is available about the assemblages of gastropods that form living communities.

Methods

During the excavations at Sadie's Cave, a series of sediment samples were taken specifically for the recovery of gastropod shells to be used in this study. The samples were taken from the west profile of Test Unit 5, located immediately inside the mouth of the cave. One sample was taken from each of six exposed strata, with the exception of Stratum 9, which is a red Pleistocene residual clay. In addition to sampling the archaeological deposits, three modern vegetation detritus samples were collected near the cave to assess the current living gastropod community in the vicinity of the site. Two of the samples (numbers 1 and 2) were collected eight and twelve meters above the caves mouth in a narrow strip of hill prairie and cedars. The third modern sample (number 3) was taken two meters below and eight meters east of the cave mouth in a mesic forest setting.

The six sediment samples from Sadie's Cave were dried and a two-liter subsample was taken from each stratum sample after the dried sample was screened to remove rock fragments larger than ¼ inch (6.35 mm). Each subsample was then subjected to water separation techniques that first remove the more buoyant complete snail shells and associated organic detritus into a separate light fraction; the remaining heavy fraction was washed through a screen. All light and heavy fraction material was retained in a Tyler #40 geologic sieve with a mesh size of 0.425 mm. The screen-captured residue from both fractions was dried and systematically searched for complete shells and identifiable fragments under a low power (10x) binocular microscope. All complete shells and potentially identifiable shell fragments were isolated from the water-screened nonsnail residue and stored until identification.

The gastropods from Sadie's Cave were sorted to taxon with reference to Burch (1962), Pilsbry (1948), and others. Following identification, shells were counted, catalogued by taxa and stored in glass vials containing labels with all pertinent taxonomic and provenience information. The taxonomic nomenclature used is that presented by Turgeon et al. (1988).

Results

The processed sediment subsamples from six Sadie's Cave strata had a total volume of 12 liters and produced 2,112 terrestrial and 5 aquatic gastropod shells. The shell density per liter of sediment ranged from 54 to 289 individuals per liter with a site average of 176 ind/liter. The combined archaeological deposits produced 28 terrestrial and one aquatic taxa (see Table 13).

Table 13. Gastropods from Sadie's Cave 1994 Excavations.

	Stratum						
	1	2A	2B	3–5	7	8	Total
Carychium exiguum (Say)	0	1	0	4	1	20	26
Columella c. alticola (Ingersoll)	0	0	0	0	1	0	1
Gastrocopta armifera (Say)	12	9	3	1	0	0	25
Gastrocopta contracta (Say)	3	21	12	5	1	5	47
Gastrocopta corticatia (Say)	8	6	7	5	1	3	30
Gastrocopta holzingeri (Sterki)	31	35	50	31	8	2	157
Gastrocopta pentodon (Say)	2	3	1	0	0	0	6
Gastrocopta procera (Gould)	24	42	23	19	4	0	112
Pupoides albilabris (C.B. Adams)	5	6	8	14	3	0	36
Vertigo tridentata Wolf	100	46	34	28	16	76	300
Vallonia perspectiva Sterki	0	0	0	0	1	3	4
Vallonia sp. [juveniles]	0	0	0	1	5	4	10
Strobilops labyrinthicus (Say)	3	0	1	0	0	2	6
Strobilops sp. [juveniles]	0	3	0	0	0	0	3
Haplotreme concavum (Say)	0	0	0	0	0	1	1
Punctum minutissimum (Lea)	50	39	54	7	3	2	155
Helicodiscus parallelus (Say)	0	0	1	0	1	2	4
Helicodiscus singleyanus (Pilsbry)	3	0	6	8	0	8	25
Anguispira alternata (Say)	0	0	0	0	3	13	16
Succineidae	59	131	58	31	9	5	293
Euconulus sp. [juveniles]	0	1	0	0	0	0	1
Glyphyalinia indentata (Say)	2	5	5	2	0	2	16
Hawaiia minuscula (Binney)	8	18	5	3	3	7	44
Nesovitrea electrina (Gould)	0	0	3	0	0	0	3
Paravitrea capsella (Gould)	2	0	0	0	0	0	2
Paravitrea sp. [juveniles]	0	1	1	0	0	0	2
Striatura cf. *S. milium* (Morwe)	0	0	1	0	0	0	1
Zonitoides arboreus (Say)	0	0	0	1	0	1	2
Deroceras laeve (Muller)	0	0	0	0	0	1	1
Mesodon inflectus (Say)	0	0	1	0	0	0	1
Polygyra dorfueilliana (Lea)	2	5	5	4	2	0	18
Terrestrial juveniles	141	206	161	102	45	109	764
Fossaria dalli (Baker)	0	0	0	0	0	2	2
Aquatic juveniles	0	0	0	0	0	3	3
Total Gastropods	**455**	**578**	**440**	**266**	**107**	**271**	**2,117**

Stratum 8 at Sadie's Cave has not been radiocarbon dated, but is assignable to the Early Archaic (pre-8000 B.P.) cultural period. Stratum 8 produced 271 individual snail shells in the two-liter sample (136 ind/liter), of which 266 were terrestrial and five were aquatic specimens. The earliest of the sampled units, the gastropod assemblage composition of Stratum 8 stands out from other strata at the site. Snail species that have their greatest abundances in this stratum include *Carychium exiguum* (Say) with 20 (77 percent) of 26 individuals and *Anquispira alternata* (Say) with 13 (81 percent) of the 16 specimens at the site. *Carychium exiguum* is a species that requires a moist microenvironment (Archer 1939:6, Harry 1951:16–33) and its abundance in Stratum 8 is a significant habitat signature. A moist setting in this stratum is also indicated by the presence of the only aquatic snails at the site, *Fossaria dalli* (Baker), a pulmonate species that is often encountered living away from standing water on wet surfaces (Leonard 1959:56).

In Stratum 8, the terrestrial snail *Vertigo tridentata* Wolf shows a marked peak in abundance. The ecology of this species is poorly understood, but it has been found on the moist, high floodplain of the Pomme de Terre River near the Rodger's Shelter 100 km northwest of Sadie's Cave, in Benton County, Missouri, where it was associated with large numbers of *Carychium exiguum* (Baerreis and Theler 1980). The only individuals of *Haplotreme concavum* (Say) and *Deroceras laeve* (Muller) in the Sadie's Cave subsample occurred in Stratum 8. Notable by their absence are those species that characterize droughty or prairie vegetation communities; these would include *Gastrocopta armifera* (Say), *Gastrocopta procera* (Gould), and *Pupoides albilabris* (C.B. Adams).

The Stratum 7 sediments were deposited during the Middle Archaic (circa 5000–7000 B.P.) cultural period. This portion of the mid-Holocene is known to have been a time of relatively warm and dry climatic conditions, a period sometimes referred to as the Hypsithermal. The two-liter sample contained 107 snail shells (54 ind/liter). The moisture-dependent taxon *Carychium exiguum* is represented by a single specimen which may be a contaminant in the rather compressed depositional sequence at Sadie's Cave. It appears that other species which show a decline in this stratum—*Vertigo tridentata*, *Gastrocopta contracta* (Say) and *Hawaiia minuscula* (Binney)—are responding to reduced available moisture or associated shifts in vegetation cover. *Hawaiia minuscula* is found in a wide range of terrestrial habitat settings from dry prairies to moist woodlands, but appears most abundant in well-drained, open deciduous woodlands.

The presence of a prairie or open woodland/savannah habitat adjacent to Sadie's Cave is documented by the first occurrences of the drought-tolerant snail species *Gastrocopta procera*, and *Pupoides albilabris*. The arrival of *G. procera* at the Modoc Rock Shelter, 200 km to the east of Sadie's Cave in southwest Illinois, is dated to about 8000 B.P., and at Rodgers Shelter the arrival is dated at circa 7500 B.P. (Theler and Baerreis 1991). Based on the known limiting factors for this taxa, it can be suggested that the frost-free period at Sadie's Cave did not exceeded 160 days until after 8000 B.P. (Baerreis 1980), perhaps corresponding with the first phases of the Hypsithermal and the spread of prairie-type vegetation communities.

A single individual of *Columella c. alticola* (Ingersoll) was recovered in Stratum 7. This specimen appears to be a Pleistocene subfossil that probably has its origins in bluff crest loess deposits above the cave. A number of loess subfossil gastropod species were documented at the Modoc Rock Shelter mid-Holocene strata (Theler and Baerreis 1991)

Stratum 3-5 was deposited during the Late Archaic (3000-5000 B.P.) and the two-liter sample from this zone contained 266 shells (133 ind/liter). The snails that occur in this zone indicate presence of a prairie-savannah vegetation community adjacent to the cave. In Stratum 3-5 the first occurrence of the drought tolerant *Gastrocopta armifera* is observed, along with a sharp increase in the prairie snail *Gastrocopta procera* and *Gastrocopta holzingeri* (Sterki). *G. holzingeri* is a taxon typical of prairie or dry savannahs and is rare in moister woodlands.

The subdivided Stratum 2 (2A and 2B) was deposited during the earlier portion of the Woodland period (circa 1630-1000 B.P.). The Stratum 2A two-liter subsample contained 578 individual snails (289 ind/liter) and the Stratum 2B two-liter sediment sample produced 440 snail shells (220 ind/liter). Stratum 2A/2B assemblages taken together are characterized by increases in *Vertigo tridentata*, *Gastrocopta contracta* and *Punctum minutissimum* (Lea). Also found in Stratum 2A/2B were the largest numbers of *Glyphyalina indentata* (Say), *Polygyra dorfueilliana* (Lea), and *Hawaiia minuscula*. In this stratum we find the first occurrence of *Gastrocopta pentodon* (Say), a species that is found living in both woodland and prairie settings. The overall signature for the Stratum 2A/2B is a rather dry setting, perhaps with hill prairies above the cave mouth and a somewhat increased mesic vegetation cover in front of the cave, when compared with strata 7 and 3/5 assemblages. This is probably an open woodland setting.

In Stratum 1 we move from the Late Woodland (circa 1000 B.P.) to the modern surface of the cave's deposits. Stratum 1 is distinguished by the highest frequency of *Vertigo tridentata* and the only specimens of *Paravitrea capsella* (Gould), although single individuals of subadult *Paravitrea* (probably *P. capsella*) do appear for the first time in Stratum 2A/2B. *Punctum minutissimum* reaches its greatest abundance in Stratum 1. Three of six *Strobilops labyrinthica* (Say) occurred in Stratum 1; this is a species that was absent from the warm/dry lower components that represent the mid-Holocene deposits. We also observe a slight decrease in *Gastrocopta procera*, *Gastrocopta holzingeri* and *Pupoides albilabris*. Stratum 1 exhibits a continuation and perhaps a slight increase of the woodlands or other protective vegetation cover in front of and/or adjacent to Sadie's Cave, while a well-drained, hill-prairie setting persists above the cave's mouth.

Modern Gastropod Community

The three modern vegetation detritus samples were collected adjacent to Sadie's Cave. A subsample of 0.5 liter was taken from each detritus sample and processed using a 0.425-mm screen mesh in a manner identical to that described for the prehistoric samples. The modern samples produced relatively few snail shells (see Table 14) making any detailed interpretations from these samples represent little more than speculation. However, the only specimens of *Paravitrea capsella*, a species interpreted to indicate a mesic late Holocene habitat in Stratum 1 at Sadie's Cave was also present in modern sample number 3 from the woodland below the cave. One indicator of dry habitat, *Gastrocopta holzingeri*, was recovered solely in sample number 2 from the modern hill prairie.

Conclusions

The gastropod assemblages recovered from the strata of Sadie's Cave span the early to late Holocene period. The changes witnessed in the Sadie's Cave assemblages are very similar to those documented at other sites along the western margin of the Midwest. These sites include Rodgers

Table 14. Gastropods from Modern Vegetation Detritus near Sadie's Cave.

	Sample Number		
	1	2	3
Gastrocopta holzingeri (Sterki)	0	2	0
Gastrocopta pentodon (Say)	0	8	1
Strobilops labyrinthicus (Say)	0	0	1
Strobilops sp. [juveniles]	3	1	0
Punctum minutissmum (Lea)	0	2	1
Euconulus fulvus (Muller)	0	0	4
Guppya sterki (Dall)	0	0	2
Glyphyalinia indentata (Say)	1	0	2
Paravitrea capsella (Gould)	0	0	2
Striatura milium (Morse)	1	0	0
Terrestrial [juveniles]	0	11	2
Totals	5	24	15

Shelter in Missouri, Modoc Rock Shelter in southwest Illinois and the Cherokee Site (Baerreis 1980) in northwest Iowa. At Sadie's Cave, like the above mentioned sites, the early Holocene is characterized by gastropod taxa associated with moist habitats (mesic woodlands ?) and perhaps cool summers with a frost-free period considerably shorter than that of today. Within the mid-Holocene sediments, a distinct shift is observed in the snail assemblage, with a reduction in numbers or complete loss of all but the most hardy, drought-tolerant gastropod species. This severe mid-Holocene stress was expressed not only as a depauperate assemblage but also one which was low in total numbers of individual gastropods recovered. A return to somewhat moister and/or cooler conditions is documented by the gastropod assemblages recovered from sediments in the later Holocene period.

Analysis of Mussel Shell

Historically, the streams and lakes of eastern North America housed the world's richest fauna of freshwater unionid mussels (Mollusca: Bivalvia: Unionoidea). More than 125 species have been documented in the Mississippi River basin, and in some favorable habitats, mussels were once so abundant that they paved the beds of streams (Baker 1928; Burch 1975; Ortmann 1926). In prehistory, Native Americans often gathered freshwater mussels for use as a food resource or as a source of raw material for the manufacture of shell artifacts, or both (Kuhm 1937; Parmalee and Klippel 1974). Several factors affected the ways mussels were used and the intensity of mussel utilization, including (1) temporal and geographical variation in the availability of exploitable mussel populations, and (2) variation within and among the economic and technological systems of different

societies. One can infer the role or roles played by mussels in prehistoric societies by analyzing mussel shell from archaeological deposits in terms of its context, condition, species composition, and relative abundance in comparison with other faunal resources. In addition to their potential significance as sources of information on prehistoric cultural behavior, mussels may also be of value as sources of information on the characteristics of past aquatic environments. Mussels often have rather specific habitat tolerances, and it is possible to develop models of past environments based on knowledge of the habitat preferences of mussel species in archaeological assemblages (Warren 1991a).

Mussel collections from the 1993 excavations have been described in previous reports (Warren 1993, 1995). The goals here are to (1) describe the 1992–94 mussel collections from Miller Cave and Sadie's Cave, and (2) discuss their cultural, biological and geological implications. Of particular interest is potential evidence of the long-term dynamics of aquatic environments along the Big Piney River. Differences have been observed between mussel collections obtained from sites located along the Big Piney River and a smaller local creek. Given these differences, one would expect to see a reflection of any major Holocene environmental changes in the Sadie's Cave mussel fauna. Elsewhere I have proposed that if drier climatic conditions during the Middle Holocene caused a decrease in the discharge of the Big Piney River, then one would predict (1) decreases in the relative abundance of large-river mussel species (e.g., *Actinonaias ligamentina*), (2) increases in the relative abundance of Ozarkian mussel species (e.g., *Lampsilis reeviana*), (3) decreases in mussel species diversity, and (4) a shift in the habitat preferences of mussel assemblages from small-river to creek environments (Warren 1995). Tests of these predictions are presented in this report.

Analytical Methods

Shells were identified at the Illinois State Museum using comparative materials from the museum's scientific collections and shells on loan to the author from the Department of Anthropology at the University of Missouri—Columbia. Identifiable shells were defined as specimens that retained the beak or umbo portion of the shell in the vicinity of the pseudocardinal tooth (see Burch 1975; Parmalee 1967), regardless of whether or not they could be identified below the family level. This criterion minimized the chances that fragmentary specimens would be counted more than once. All specimens lacking the beak or umbo portion of the shell were considered unidentifiable. Identifiable specimens were counted and weighed for each provenience unit. Taxonomic nomenclature follows Turgeon et al. (1988), except for revisions to the Subfamily Anodontinae proposed by Hoeh (1990).

Models of past aquatic environments were developed using a systematic, quantitative approach that transformed the compositional data of mussel assemblages into habitat scores using a weighting system that reflects the habitat preferences of different species (Warren 1991a). Habitat scores were calculated with UNIO, a spreadsheet program that carries out the transformation on either qualitative or quantitative compositional data (Warren 1992a). The scores reported here are based on qualitative data (%TAXA: the relative abundance of species in each assemblage).

Statistical correlations were calculated for nonlinear regressions ($y = a + bx^c$) on a personal computer using the TableCurve for Windows statistical package. Other statistical tests were run using the SigmaStat for Windows statistical package.

The Mussel Assemblages

A large collection of freshwater mussel shell was recovered from Miller Cave and a smaller collection from Sadie's Cave. Together, the analyzed portions of the two assemblages consist of 1,628 g of unidentifiable shell, 3,932 g of identifiable shell, and 1,506 identifiable specimens.

Miller Cave. Mussel shell was recovered from Trench 1 and Test Unit 1 at Miller Cave. Trench 1 contained both disturbed and undisturbed deposits, the latter dating to the Early Archaic period. Deposits in Test Unit 1 were undisturbed, although they represent more than one cultural period (Archaic and Late Woodland). To date, I have examined all the mussel shell from undisturbed deposits at Miller Cave (Table 15) but only a small sample of the shell from disturbed deposits (Table 16). The analyzed Miller Cave collection consists of 950.6 g of unidentifiable shell, 2,945.7 g of identifiable shell, and 1,029 identifiable specimens. An additional 130 identifiable specimens were recovered from a surface collection in October 1994.

It is difficult to assess variation in shell density at Miller Cave because sediment volume has not been reported for all excavation units (cf. Markman 1993: 85–86). In the undisturbed Zone 2 deposits of Trench 1 (Section 2, Area A, levels 6–7; total sediment volume=200 liters), which date to the Early Archaic period, shell density was 1.046 g/liter and 0.12 NISP/liter (Number of Identifiable Specimens/liter). In the underlying Zone 3 deposits of Trench 1 (Area A, Level 8; Area B, levels 6–8; East ½, levels 9–11; total sediment volume=75 liters), shell density was 0.04 g/liter and 0.013 NISP/liter. In the undisturbed Zone 1 deposits of Test Unit 1 (levels 1–8; total sediment volume=1,300 liters), which date to the Archaic and Late Woodland periods, shell density was 0.297 g/liter and 0.062 NISP/liter. In the underlying Zone 2 deposits of Test Unit 1 (Level 9; total sediment volume=100 liters) shell density was 0.047 g/liter and 0.01 NISP/liter.

Nineteen species are represented in the Miller Cave mussel assemblage (Table 17). The three most abundant species are the ellipse, *Venustaconcha ellipsiformis* (Conrad 1836), the spike, *Elliptio dilatata* (Rafinesque 1820), and the broken-ray, *Lampsilis reeviana* (Lea 1852), which together comprise 80.3 percent of the total assemblage (Figure 42). These taxa are the leading dominant species in all of the analyzed samples from the disturbed deposits in Trench 1 (levels 1–3) and in the 1994 surface collection at the site (Table 18). They also are relatively abundant in the undisturbed Early Archaic deposits in Trench 1 (zones 2–3, levels 6–11), although two species in that small sample—*Actinonaias ligamentina* (Lamarck 1819) and *Lampsilis cardium* (Rafinesque 1820)—are tied with *L. reeviana* as the third leading dominant species. The only clear deviation from the prevailing pattern is in the undisturbed Archaic and Late Woodland deposits in Test Unit 1 (zones 1–2, levels 1–9), where *Fusconaia flava* (Rafinesque 1820) is much more abundant than *L. reeviana.*

The *Amblema plicata* (Say 1817) sample from Miller Cave includes one relatively complete specimen with a reduced beak and a laterally compressed valve (92–155). This specimen clearly associates with the small-stream ecomorph of the species, *A. plicata* form *costata* (Rafinesque 1820) (see Ball 1922). Similarly, the *Fusconaia flava* sample includes a number of complete shells that have reduced beaks, laterally compressed valves, and have no trace of a radial sulcus on the lateral surface of the shell. These specimens associate with the small-stream ecomorph of that species, *F. flava* form *flava* (see Stansbery 1983).

Table 15. Freshwater Unionid Mussel Shell from Undisturbed Deposits at Miller Cave.

Excavation unit[1]	Level	Cat. No.	Unidentifiable Shell (g)	Identifiable Shell: Weight (g)	Identifiable Shell: Count (NISP)[2]	Identifiable Shell: Charred (NISP)[2]	Identifiable Shell: Taxa[3]
Trench 1 (Sect. 2)	6 (Zone 2)	201	117.7	91.3	24	1	*Actinonaias ligamentina* (1L, 1R); *Amblema plicata* (1L); *Elliptio dilatata* (2L, 4R); *Lampsilis cardium* (1L); cf. *L. cardium* (1R); cf. *L. reeviana* (1L); *Lampsilis* sp. (1R); *Venustaconcha ellipsiformis* (4L, 7R).
Trench 1 (Sect. 2)	6 (Zone 3)	217	0.9	-	-	-	
Trench 1 (Sect. 2)	7 (Zone 2)	221	0.3	-	-	-	
Trench 1 (Sect. 2)	8 (Zone 3)	227	0.3	-	-	-	
Trench 1 (Sect. 2)	9 (Zone 3)	231	0.6	-	-	-	
Trench 1 (Sect. 2)	10 (Zone 3)	233	0.3	2.5	1	1	*Lampsilis reeviana* (1R).
Trench 1 (Sect. 2)	11 (Zone 3)	237	0.4	-	-	-	
TU 1	1	91	1.3	4.7	3	0	*Elliptio dilatata* (2L, 1R).
TU 1	2	98	10.3	10.5	7	0	*Elliptio dilatata* (2L, 1R); *Fusconaia flava* (1L); *Venustaconcha ellipsiformis* (3R).
TU 1	3	105	24.1	33.8	12	0	*Elliptio dilatata* (3R); *Fusconaia flava* (1R); *Lampsilis reeviana* (1R); *Lampsilis* sp. (1L); *Pleurobema coccineum* (1L); *Venustaconcha ellipsiformis* (2R); Unionidae spp. (2L, 1R).
TU 1	4	113	24.4	38.5	17	0	cf. *Alasmidonta viridis* (1L); *Elliptio dilatata* (2L, 3R); *Fusconaia flava* (1L, 1R); cf. *F. flava* (1L); *Lampsilis* sp. (2L); *Lasmigona costata* (1R); *Venustaconcha ellipsiformis* (4R); Unionidae sp. (1L).

Table 15. Concluded.

Excav-ation unit[1]	Level	Cat. No.	Unident-ifiable Shell (g)	Identifiable Shell Weight (g)	Count (NISP)[2]	Charred (NISP)[2]	Taxa[3]
TU 1	5	135	10	19	9	0	*Elliptio dilatata* (1R); *Fusconaia flava* (1L, 1R); cf. *F. flava* (1R); *Lampsilis cardium* (1L); *Lampsilis* sp. (1L); *Venustaconcha ellipsiformis* (2L); Unionidae sp. (1R).
TU 1	6	147	7.7	18.9	4	0	*Amblema plicata* (1L); *Elliptio dilatata* (1L); *Venustaconcha ellipsiformis* (1R); Unionidae sp. (1R).
TU 1	7	152	8.7	50.4	6	0	*Amblema plicata* (1R); *Elliptio dilatata* (1L, 2R); cf. *Fusconaia flava* (1R); *Venustaconcha ellipsiformis* (1R).
TU 1	8	155	5.2	54.7	8	0	*Amblema plicata* (1L); cf. *Fusconaia flava* (1R); cf. *Lampsilis cardium* (1L); cf. *Lasmigona costata* (1R); *Venustaconcha ellipsiformis* (3R); Unionidae sp. (1L).
TU 1	9	160	2.1	2.6	1	0	*Venustaconcha ellipsiformis* (1R).
TU 1 Ext. 1	1	121A	10.5	20.6	8	0	*Fusconaia flava* (1R); *Lasmigona costata* (1L); cf. *Pleurobema coccineum* (1R); *Venustaconcha ellipsiformis* (3L, 2R).
TU 1 Ext. 1	2	140	10.8	21.9	6	0	*Elliptio dilatata* (1L, 1R); *Lampsilis* sp. (1L); *Venustaconcha ellipsiformis* (3L).
Total			**235.6**	**369.4**	**106**	**2**	

[1] TU is Test Unit.
[2] NISP is number of identified specimens.
[3] L is left valve; R is right valve.

Table 16. Freshwater Unionid Mussel Shell from Disturbed Deposits at Miller Cave.

Excavation unit[1]	Level	Cat. No.	Unidentifiable Shell (g)	Identifiable Shell Weight (g)	Identifiable Shell Count (NISP)[2]	Identifiable Shell Charred (NISP)[2]	Identifiable Shell Taxa[3]
Trench 1 (Sect. 2)	1	323	56.4	128.8	41	9	*Alasmidonta viridis* (1R); *Elliptio dilatata* (7L, 10R); *Lampsilis cardium* (1L, 3R); *L. reeviana* (2R); *Lampsilis* sp. (1L); cf. *Ligumia recta* (1L); *Pleurobema coccineum* (1L); *Strophitus undulatus* (1R); *Venustaconcha ellipsiformis* (10L, 3R).
Trench 1 (Sect. 2)	1	329	220.8	453.9	207	45	*Actinonaias ligamentina* (1L, 2R); *Alasmidonta viridis* (2L, 2R); *Elliptio dilatata* (28L, 30R); *Fusconaia flava* (7L, 4R); *Lampsilis cardium* (5L, 2R); *L. reeviana* (13L, 11R); *Lampsilis* spp. (2L, 2R); *Lasmigona costata* (1L, 3R); *Ligumia subrostrata* (2R); *Pleurobema coccineum* (1L); *Quadrula metanevra* (2L); *Strophitus undulatus* (3L, 2R); *Tritogonia verrucosa* (1R); *Venustaconcha ellipsiformis* (35L, 40R); Unionidae spp. (3L, 3R).
Trench 1 (Sect. 2)	2	338	49.8	161.1	56	10	*Elliptio dilatata* (11L, 9R); *Fusconaia flava* (2L); *Lampsilis cardium* (1L, 2R); *L. reeviana* (4L, 3R); *Strophitus undulatus* (1R); *Venustaconcha ellipsiformis* (13L, 10R).
Trench 1 (Sect. 2)	3	358	50.3	499.5	135	20	*Alasmidonta marginata* (1L); *Elliptio dilatata* (24L, 25R); *Fusconaia flava* (2L); *Lampsilis cardium* (9R); *L. reeviana* (11L, 7R); *Lampsilis* sp. (1R); *Pleurobema coccineum* (1L); *Quadrula metanevra* (1L); *Strophitus undulatus* (1L, 1R); *Venustaconcha ellipsiformis* (20L, 27R); Unionidae spp. (3L, 1R).

Table 16. Concluded.

Excavation unit[1]	Level	Cat. No.	Unidentifiable Shell (g)	Identifiable Shell Weight (g)	Identifiable Shell Count (NISP)[2]	Identifiable Shell Charred (NISP)[2]	Identifiable Shell Taxa[3]
Trench 1 (Sect. 2)	3	362	337.7	1333	484	125	*Alasmidonta marginata* (5L, 2R); *A. viridis* (2L); *Elliptio dilatata* (77L, 71R); *Fusconaia flava* (5L, 4R); *Lampsilis cardium* (11L, 10R); *L. reeviana* (30L, 28R); *L. siliquoidea* (2R); *Lampsilis* spp. (4R); *Lasmigona costata* (1L, 1R); *Ligumia recta* (1L [modified], 1R); *Pleurobema coccineum* (2L, 2R); *Pyganodon grandis* (1L); *Quadrula metanevra* (1L, 2R); *Q. pustulosa* (1R); *Strophitus undulatus* (8L, 9R); *Venustaconcha ellipsiformis* (94L, 103R); Unionidae spp. (2L, 4R).
Total			**715**	**2576.3**	**923**	**209**	

[1] TU is Test Unit.
[2] NISP is number of identified specimens.
[3] L is left valve; R is right valve.

Table 17. Summary of Freshwater Mussels from Excavations and Surface Collections at Miller Cave (1992 and 1994).

Taxon	Left Valves	Right Valves	Total	Percent
Subfamily Anodontinae				
Alasmidonta marginata Say 1818	6	4	10	0.9
Alasmidonta viridis (Rafinesque 1820)	5	3	8	0.7
Lasmigona costata (Rafinesque 1820)	3	6	9	0.8
Pyganodon grandis (Say 1829)	1	0	1	0.1
Strophitus undulatus (Say 1817)	13	14	27	2.3
Subfamily Ambleminae				
Amblema plicata (Say 1817)	3	1	4	0.3
Elliptio dilatata (Rafinesque 1820)	174	171	345	29.8
Fusconaia flava (Rafinesque 1820)	22	18	40	3.5
Pleurobema coccineum (Conrad 1834)	6	3	9	0.8
Quadrula metanevra (Rafinesque 1820)	5	3	8	0.7
Quadrula pustulosa (Lea 1831)	0	1	1	0.1
Tritogonia verrucosa (Rafinesque 1820)	0	1	1	0.1
Subfamily Lampsilinae				
Actinonaias ligamentina (Lamarck 1819)	3	4	7	0.6
Lampsilis cardium (Rafinesque 1820)	23	29	52	4.5
Lampsilis reeviana (Lea 1852)	70	57	127	11.0
Lampsilis siliquoidea (Barnes 1823)	0	2	2	0.2
Lampsilis spp.	10	11	21	1.8
Ligumia recta (Lamarck 1819)	2	1	3	0.3
Ligumia subrostrata (Say 1831)	0	2	2	0.2
Venustaconcha ellipsiformis (Conrad 1836)	223	236	459	39.6
Unionidae spp.	12	11	23	2.0
Total	**581**	**578**	**1,159**	**100.3**

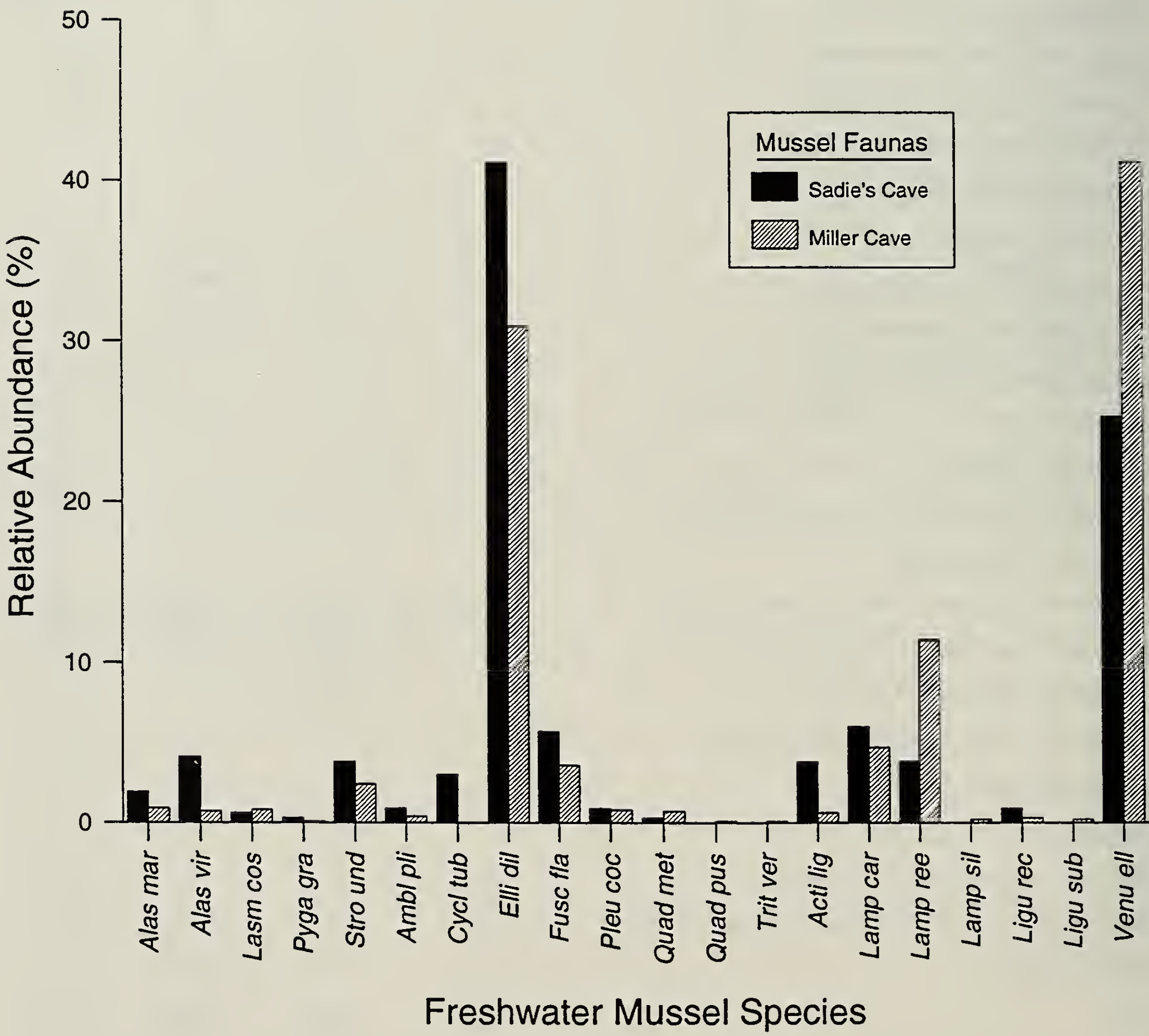


Figure 42. Comparison of the Relative Abundance of Freshwater Mussel Species from Miller Cave and Sadie's Cave. The two patterns correlate significantly with one another ($r_{Pearson}$ = 0.91; df = 18; $p < 0.001$).

Table 18. Stratigraphic Distribution of Unionid Mussel Shell from Miller Cave.

Taxon	Trench 1 L.1[a]	Trench 1 L.2[a]	Trench 1 L.3[a]	Trench 1 L.6-11[b]	TU 1 L.1–9[c]	Surface 10/94	Total
Anodontinae							
Alasmidonta marginata	0	0	8	0	0	2	10
Alasmidonta viridis	5	0	2	0	1	0	8
Lasmigona costata	4	0	2	0	3	0	9
Pyganodon grandis	0	0	1	0	0	0	1
Strophitus undulatus	6	1	19	0	0	1	27
Ambleminae							
Amblema plicata	0	0	0	1	3	0	4
Elliptio dilatata	75	20	197	6	21	26	345
Fusconaia flava	11	2	11	0	11	5	40
Pleurobema coccineum	2	0	5	0	2	0	9
Quadrula metanevra	2	0	4	0	0	2	8
Quadrula pustulosa	0	0	1	0	0	0	1
Tritogonia verrucosa	1	0	0	0	0	0	1
Lampsilinae							
Actinonaias ligamentina	3	0	0	2	0	2	7
Lampsilis cardium	11	3	30	2	2	4	52
Lampsilis reeviana	26	7	76	2	1	15	127
Lampsilis siliquoidea	0	0	2	0	0	0	2
Lampsilis sp.	5	0	5	1	5	5	21
Ligumia recta	1	0	2	0	0	0	3
Ligumia subrostrata	2	0	0	0	0	0	2
Venustaconcha ellipsiformis	88	23	244	11	25	68	459
Unionidae spp.	6	0	10	0	7	0	23
Total	**248**	**56**	**619**	**25**	**81**	**130**	**1,159**

[a] Disturbed deposits (Zone 1).
[b] Undisturbed deposits (Zones 2–3: Early Archaic).
[c] Undisturbed deposits (Zones 1–2: Archaic and Late Woodland).

Most of the *Lampsilis reeviana* specimens from Miller Cave are fragmentary and cannot be associated with any of the three subspecies of this mussel. However, several complete valves of female *L. reeviana* (e.g., 92–358, 92–362) exhibit the biangulate post-ventral margin and the pronounced radial sulcus below the posterior ridge that are diagnostic of the northern broken-ray, *L. reeviana brittsi* Simpson 1900 (see Oesch 1984).

One complete left valve identified as *Venustaconcha ellipsiformis* has a deep, wide radial sulcus or furrow on the lateral surface below the posterior ridge (92–362). The furrow is similar to that of the bleedingtooth mussel, *V. pleasi* (Marsh 1891), an endemic Ozarkian species that occurs today on the south flank of the Ozark Highland in southern Missouri and northern Arkansas (Oesch 1984). However, shallow radial furrows are fairly common on prehistoric *Venustaconcha* shells from the Fort Leonard Wood area, and the furrowed shells are thicker and more compressed than modern shells of *V. pleasi* (Warren 1995). It is assumed here that all of the furrowed prehistoric *Venustaconcha* shells from Miller Cave are associated with *V. ellipsiformis* form *venusta* (Lea 1838), a furrowed variant that Utterback (1916) recognized in the Meramec and Niangua rivers in Missouri.

Sadie's Cave. Mussel shell was recovered from all seven test units at Sadie's Cave. I have examined all of the Sadie's Cave mussel collection, which consists of 677.4 g of unidentifiable shell, 986.7 g of identifiable shell, and 347 identifiable specimens. Table 19 lists the basic analytical data for each provenience unit that yielded mussel shell at Sadie's Cave. The data are organized by strata set (A-E) and by analytical unit.

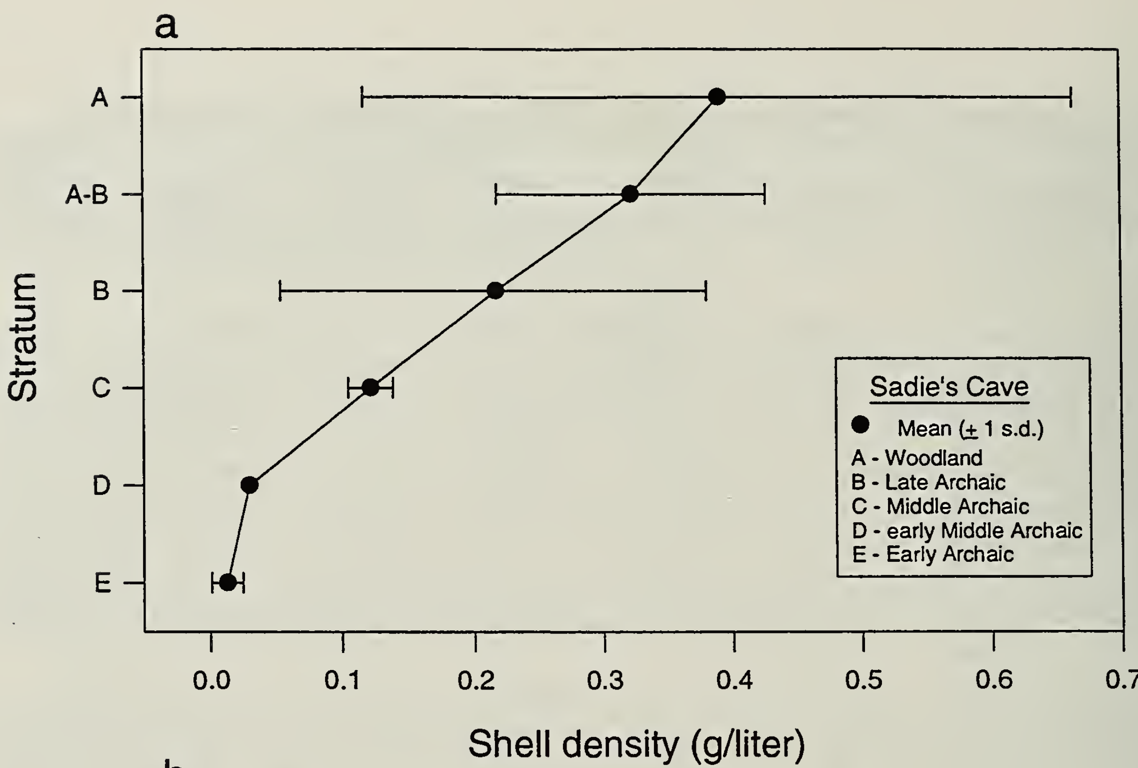
Weights and counts of mussel shell are summarized in Table 19 for each analytical unit at Sadie's Cave. Figure 43 plots the mean densities of mussel shell in the general (nonfeature) fill of each stratum. The plot of shell weight (Figure 43a) shows a monotonic increase in the density of shell from Strata Set E (Early Archaic) to Strata Set A (Woodland); the plot of shell frequency (Figure 43b) is very similar but has minor reversals at the upper and lower ends of the sequence. The Mann-Whitney Rank Sum test was used to compare the shell densities of the various strata sets. With reference to both shell weight (g/liter) and shell frequency (NISP/liter), Strata Set E is significantly less dense than strata sets A, A/B and B ($p < 0.05$). Hence, the apparent increase in shell density through time appears to be valid. Mussel shell is significantly more dense in the Woodland and Late Archaic strata than in the Early Archaic stratum.

Features were sampled separately in strata sets A (n=5), B (n=4), and C (n=1) at Sadie's Cave. The mean density of shell in feature fill is greater than the mean density of shell in the general fill of each of these strata sets (Strata Set A: general=0.390±0.273 g/liter, features=3.668±7.882 g/liter; Strata Set B: general=0.217±0.163 g/liter, features=0.259 ±0.177 g/liter; Strata Set C: general=0.112 ±0.017 g/liter, feature=0.383 g/liter). However, statistical comparisons using the Mann-Whitney Rank Sum test indicate there are no significant differences between the median values of shell density for general fill vs. feature fill in each stratum (Strata Set A: $p_{weight} = 0.524$, $p_{nisp} = 0.171$; Strata Set B: $p_{weight} = 0.730$, $p_{nisp} = 0.556$; Strata Set C: $p_{weight} = 0.667$, $p_{nisp} = 0.667$). Figure 44 plots the distributions of weight density for general fill vs. feature fill in Strata Sets A and B. Although the differences in means (dotted lines) are evident, there are no significant differences between the medians or the overall distributions.

Table 19. Abundance of Unionid Mussel Shell from Excavated Sediments at Sadie's Cave.

Strata Set	Analytical unit[1]	Volume (liters)	Unidentifiable shell (g)	Identifiable shell (g)	Total shell (g)	Identifiable shell (NISP)[2]	Charred identifiable shell (NISP)
	TU2/S1	579	94.2	184.5	278.7	54	5
A	TU2/F112	3	8.3	45.0	53.3	2	2
A-B	TU2/L4	167	15.8	18.6	34.4	9	1
B	TU2/S2	456	24.9	34.3	59.2	20	1
B	TU2/F104	6	0.1	0	0.1	0	0
C	TU2/S3	625	42.5	35.2	77.7	19	1
C	TU2/F2	114	18.4	25.3	43.7	10	0
D	TU2/S5	266	3.5	4.4	7.9	2	0
E	TU2/S7	27	0.2	0	0.2	0	0
A	TU3/S1	193	42.1	125.2	167.3	21	0
A	TU3/F4	12	3.1	0	3.1	0	0
A-B	TU3/L3	93	7.6	7.1	14.7	6	0
B	TU3/S2	185	21.3	28.9	50.2	17	0
B	TU3/S3	92	1.2	1.1	2.3	1	0
B	TU3/F5	7	0.4	2.7	3.1	1	0
E	TU3/L7	127	0.1	1.4	1.5	1	0
A	TU5/S1	175	15.5	22.8	38.3	8	0
A	TU5/S2	186	10.1	16.5	26.6	6	3
A	TU5/S2A	155	19.9	16.2	36.1	8	0
A	TU5/S2B	114	3.0	3.3	6.3	2	0
A	TU5/L4	85	18.4	31.4	49.8	22	11
A	TU5/F6	15	0.3	0	0.3	0	0
A	TU5/F8	7	0.6	0	0.6	0	0
A	TU5/F101	27	2.7	3.0	5.7	1	0
A-B	TU5/L6	30	6.1	12.4	18.5	5	1
B	TU5/S3-5	591	54.3	64.6	118.9	61	24
B	TU5/F3	9	2.5	0	2.5	0	0
B	TU5/F9	22	4.1	2.5	6.6	2	0
B-C	TU5/L11	65	10.4	14.7	25.1	4	0
C	TU5/S7	247	8.3	16.5	24.8	9	0
E	TU5/S8	219	0.9	0	0.9	0	0
A	TU7/S1	100	45.0	8.6	53.6	8	0
A-B	TU7/L2	92	10.2	18.1	28.3	12	0
B	TU7/S3	70	22.5	9.7	32.2	9	0
E	TU7/S4	29	0	0.9	0.9	1	0
Total		**5190**	**518.5**	**754.9**	**1,273.4**	**321**	**49**

[1] TU is Test Unit; S is Stratum; F is Feature; L is Level.
[2] NISP is number of identified specimens.



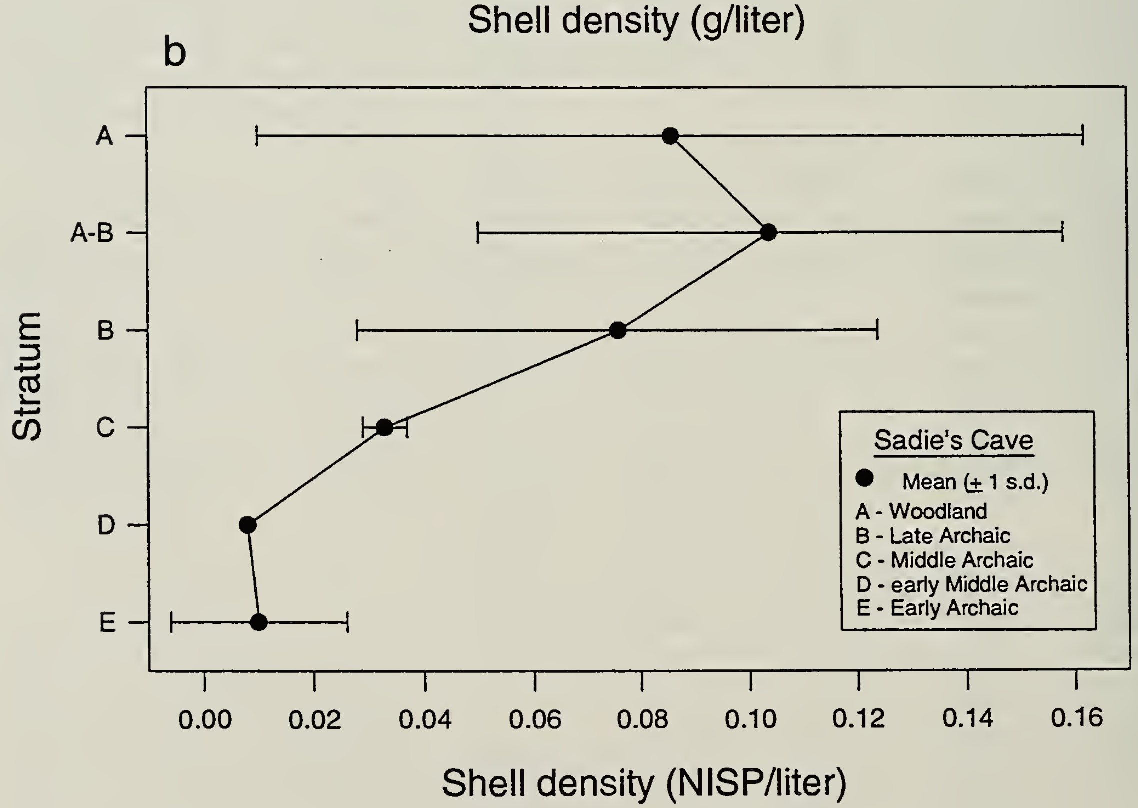


Figure 43. Stratigraphic Variation in the Density of Unionid Mussel Shell at Sadie's Cave: a, weight of identifiable and unidentifiable shell (g/liter) in six strata sets (A-E); b, counts of identifiable shell (NISP/liter) in strata sets A-E. The data shown are means (± 1 standard deviation) of general fill; feature data were excluded. The two patterns correlate significantly with one another ($r_{Pearson} = 0.96$; df $= 4$; $p < 0.01$).

The Sadie's Cave mussel assemblage includes 16 species (Table 20). Two taxa predominate: the spike, *Elliptio dilatata* (37.5 percent), and the ellipse, *Venustaconcha ellipsiformis* (23.1 percent). Together, these species comprise about 60 percent of the assemblage. They are among the leading dominant species in all of the strata that contained 30 or more shells (Table 21), although *Actinonaias ligamentina* is as abundant as *V. ellipsiformis* in the sample of 30 shells from mixed or surficial proveniences. Other common taxa include the plain pocketbook, *Lampsilis cardium* (5.5 percent); the Wabash pigtoe, *Fusconaia flava* (5.2 percent); and the slippershell mussel, *Alasmidonta viridis* (3.7 percent).

Specimens of *Amblema plicata* and *Fusconaia flava* from Sadie's Cave are associated with the same small-stream ecomorphs that occur at Miller Cave: *A. plicata* form *costata* and *F. flava* form *flava*. Also, several specimens of *Venustaconcha ellipsiformis* with shallow radial furrows below the posterior ridge have been observed in the Sadie's Cave mussel assemblage (Warren 1995).

Modified Valves

Only one of the 1,506 identifiable mussel shells from the 1992–94 test excavations at Miller Cave and Sadie's Cave shows any trace of artifactual modification. This specimen is a left valve of a black-sandshell mussel, *Ligumia recta* (Lamarck 1819), which was recovered from disturbed deposits at Miller Cave (Trench 1, Section 2, Level 3; 92-362). The shell has numerous scratch marks running parallel to the ventral margin on its medial surface below the lateral teeth. The posterior end of the shell is truncated vertically through the posterior adductor muscle scar. Its posterior margin is somewhat worn but not smooth or polished. The shell may have been used as a scraper or small container, although its true function is unknown. A small unidentifiable fragment of a shell artifact was also recovered from the same excavation unit at Miller Cave (92–362). This specimen has numerous parallel scratch marks covering its medial surface, and some wear and additional scratch marks on its lateral surface. It is a fragment of a large unionid mussel, possibly *Lampsilis cardium*, a species that was commonly used in prehistory as a spoon.

Approximately 20 percent of the identifiable shells from Miller Cave and 15 percent of the identifiable shells from Sadie's Cave are discolored gray or black due to charring (Tables 15, 16 and 19). However, there is a considerable amount of variation among excavation units in the incidence of charred shell. At Miller Cave the rate of charring is relatively low in the undisturbed deposits (8.0 percent in the Early Archaic levels of Trench 1; 0 percent in the mixed Archaic and Late Woodland levels of Test Unit 1) but is higher in the disturbed deposits (22.6 percent in Trench 1, levels 1–3). The rate of charring is also variable at Sadie's Cave, where there appears to be a general increase in charring through time (Strata Set A: 15.9 percent; Strata Set B: 22.5 percent; Strata Set C: 2.6 percent; Strata Set D: 0 percent; Strata Set E: 0 percent). Chi-square analysis indicates there is only about one chance in 100 that the observed increase in charring is due to chance ($\chi^2 = 9.04$; df = 2; $p = 0.011$).

Species Composition

Fifteen species of unionid mussels have been documented historically in the Big Piney River (Table 22). Oesch (1984) documents 13 species in his book on the freshwater mussels of Missouri. Ten species are represented in a sample of dead shells collected by R. B. McMillan in the headwaters of the Big Piney River at Simmons Ford in southern Texas County. Two species in the McMillan

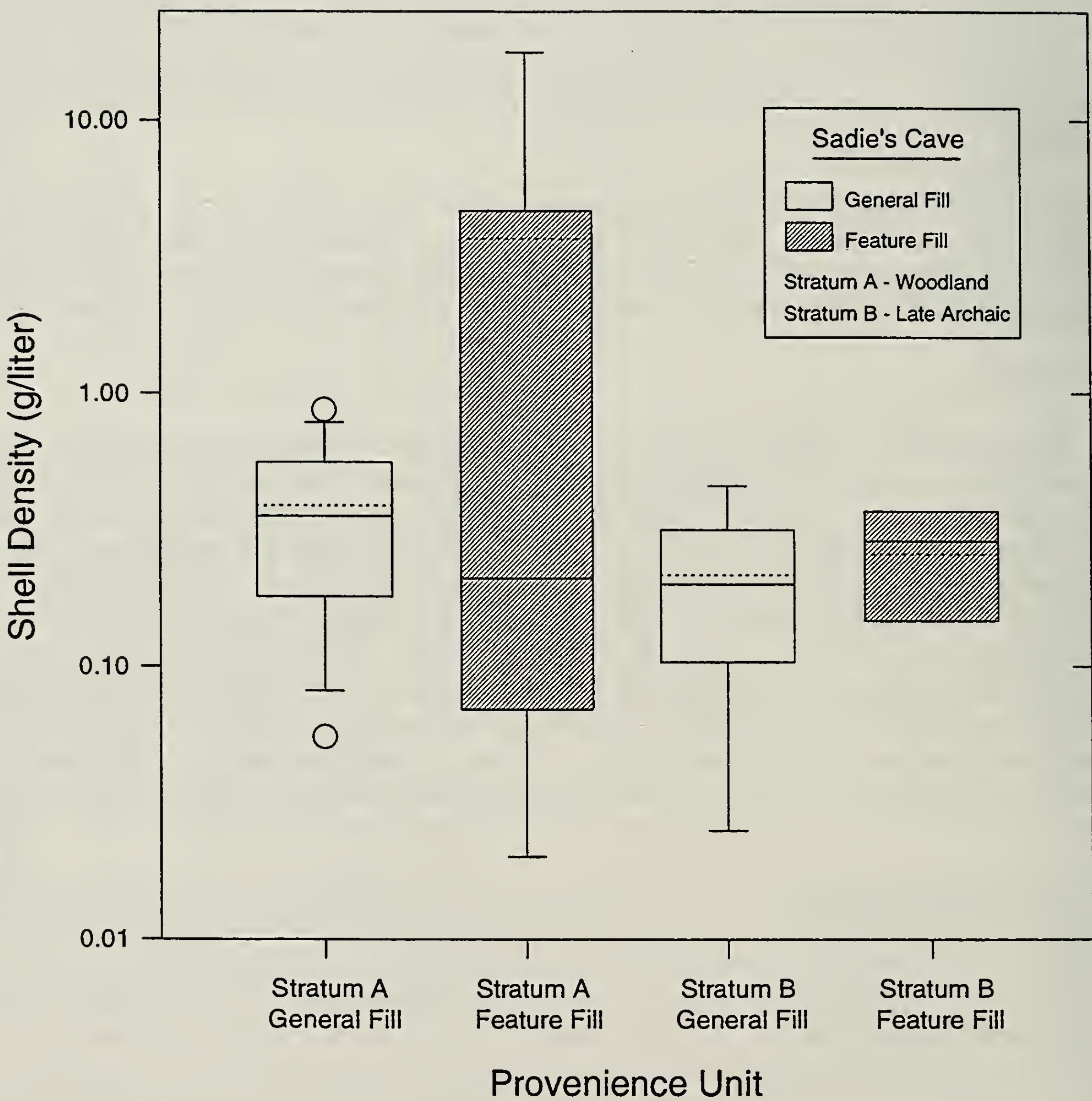


Figure 44. Box Plots Showing Variation in the Density of Unionid Mussel Shell in General Fill and Feature Fill at Sadie's Cave, Strata Sets A and B. The data illustrated are weights of identifiable and unidentifiable shell (g/liter). The Mann-Whitney Rank Sum test indicates there are no significant differences between general fill and feature fill in the two strata. Medians are horizontal solid lines; means are horizontal dotted lines; lower and upper box boundaries are the 25th and 75th percentiles; lower and upper whiskers are the 10th and 90th percentiles; open circles are outliers.

Table 20. Summary of Freshwater Unionid Mussel Shell from Excavations and Surface Collections at Sadie's Cave (1993–94).

Taxon	Left valves	Right valves	Total	Percent
Subfamily Anodontinae				
Alasmidonta marginata Say 1818	4	2	6	1.7
Alasmidonta viridis (Rafinesque 1820)	6	7	13	3.7
Lasmigona costata (Rafinesque 1820)	2	0	2	0.6
Pyganodon grandis (Say 1829)	1	0	1	0.3
Strophitus undulatus (Say 1817)	3	9	12	3.5
Subfamily Ambleminae				
Amblema plicata (Say 1817)	1	2	3	0.9
Cyclonaias tuberculata (Rafinesque 1820)	1	0	1	0.3
Elliptio dilatata (Rafinesque 1820)	63	67	130	37.5
Fusconaia flava (Rafinesque 1820)	7	11	18	5.2
Pleurobema coccineum (Conrad 1834)	3	0	3	0.9
Quadrula metanevra (Rafinesque 1820)	0	1	1	0.3
Subfamily Lampsilinae				
Actinonaias ligamentina (Lamarck 1819)	6	6	12	3.5
Lampsilis cardium (Rafinesque 1820)	13	6	19	5.5
Lampsilis reeviana (Lea 1852)	8	4	12	3.5
Lampsilis spp.	7	7	14	4
Ligumia recta (Lamarck 1819)	0	3	3	0.9
Venustaconcha ellipsiformis (Conrad 1836)	40	40	80	23.1
Unionidae spp.	12	5	17	4.9
Total	177	170	347	100.30

Table 21. Stratigraphic Distribution of Unionid Mussel Shell from Sadie's Cave.

	Strata Set[1]							
Taxon	A	A-B	B	C	D	E	Other	Total
Anodontinae								
Alasmidonta marginata	4	0	0	0	0	0	2	6
Alasmidonta viridis	3	1	7	1	0	0	1	13
Lasmigona costata	2	0	0	0	0	0	0	2
Pyganodon grandis	1	0	0	0	0	0	0	1
Strophitus undulatus	5	3	3	0	0	0	1	12
Ambleminae								
Amblema plicata	1	0	1	0	0	0	1	3
Cyclonaias tuberculata	1	0	0	0	0	0	0	1
Elliptio dilatata	45	8	49	18	0	2	8	130
Fusconaia flava	3	6	6	1	1	0	1	18
Pleurobema coccineum	0	0	2	1	0	0	0	3
Quadrula metanevra	1	0	0	0	0	0	0	1
Lampsilinae								
Actinonaias ligamentina	5	0	1	0	0	0	6	12
Lampsilis cardium	10	0	4	2	0	0	3	19
Lampsilis reeviana	9	1	1	1	0	0	0	12
Lampsilis sp.	6	1	4	2	0	0	1	14
Ligumia recta	2	0	0	1	0	0	0	3
Venustaconcha ellipsiformis	28	10	27	8	1	0	6	80
Unionidae spp.	6	2	6	3	0	0	0	17
Total	132	32	111	38	2	2	30	347

[1] Stratum A: Middle-Late Woodland period (950–1750 years B.P.); Stratum B: Late Archaic period (3000–5000 years B.P.); Stratum C: Middle Archaic period (5000–7000 years B.P.); Stratum D: early Middle Archaic period (7000–8000 years B.P.); Stratum E: Early Archaic period (pre-8000 years B.P.).

Table 22. Freshwater Mussels in the Big Piney River System, Missouri.

Taxon	Historic: Oesch[a]	Historic: McMillan[b]	Prehistoric: Sadie's Cave	Prehistoric: Miller Cave
Subfamily Anodontinae				
1. *Alasmidonta marginata* Say 1818	-	-	6	10
2. *Alasmidonta viridis* (Rafinesque 1820)	-	-	13	8
3. *Lasmigona costata* (Rafinesque 1820)	X	2	2	9
4. *Pyganodon grandis* (Say 1829)	X	-	1	1
5. *Strophitus undulatus* (Say 1817)	X	1	12	27
Subfamily Ambleminae				
6. *Amblema plicata* (Say 1817)	-	-	3	4
7. *Cyclonaias tuberculata* (Rafinesque 1820)	-	-	1	-
8. *Elliptio dilatata* (Rafinesque 1820)	X	1	130	345
9. *Fusconaia flava* (Rafinesque 1820)	X	6	18	40
10. *Pleurobema coccineum* (Conrad 1834)	-	1	3	9
11. *Quadrula metanevra* (Rafinesque 1820)	X	-	1	8
12. *Quadrula pustulosa* (Lea 1831)	-	-	-	1
13. *Tritogonia verrucosa* (Rafinesque 1820)	-	-	-	1
Subfamily Lampsilinae				
14. *Actinonaias ligamentina* (Lamarck 1819)	X	-	12	7
15. *Lampsilis cardium* (Rafinesque 1820)	X	7	19	52
16. *Lampsilis reeviana* (Lea 1852)	X	16	12	127
17. *Lampsilis siliquoidea* (Barnes 1823)	-	2	-	2
18. *Ligumia recta* (Lamarck 1819)	X	-	3	3
19. *Ligumia subrostrata* (Say 1831)	X	2	-	2
20. *Potamilus alatus* (Say 1817)	X	-	-	-
21. *Venustaconcha ellipsiformis* (Conrad 1836)	X	15	80	459
Total number of specimens	-	53	316	1115
Total number of species	13	10	16	19

[a] Recent collections reported by Oesch (1984); X is present, - is absent.
[b] Collection by R. B. McMillan at Simmons Ford, Texas County, Missouri (17 June 1991).

collection—*Pleurobema coccineum* (Conrad 1834) and *Lampsilis siliquoidea* (Barnes 1823)—were not documented by Oesch in the Big Piney but occur elsewhere in the Gasconade River drainage (Oesch 1984).

Of the 20 species that occur in the Miller Cave and Sadie's Cave prehistoric collections, 15 are represented in the historical collections. Six species occur only in the archaeological samples. These include the elktoe, *Alasmidonta marginata* (Say 1818), the slippershell, *Alasmidonta viridis* (Rafinesque 1820), and the threeridge, *Amblema plicata* (Say 1817), which occur in both cave assemblages. The pimpleback, *Quadrula pustulosa* (Lea 1831), and the pistolgrip, *Tritogonia verrucosa* (Rafinesque 1820), have been recovered only at Miller Cave, whereas the purple wartyback, *Cyclonaias tuberculata* (Rafinesque 1820) has been identified to date only from Sadie's Cave. Five of the six extralimital species have been documented by Oesch (1984) elsewhere in the Gasconade River system. The lone exception, *A. viridis*, has been documented in the Gasconade system only in prehistoric collections (Warren 1995).

The relative abundances of mussel species are similar at Miller Cave and Sadie's Cave (Figure 42). This is confirmed by a significant correlation between the NISP values of the nine most abundant species at the two sites (*Alasmidonta marginata, A. viridis, Strophitus undulatus, Elliptio dilatata, Fusconaia flava, Actinonaias ligamentina, Lampsilis cardium, L. reeviana, Venustaconcha ellipsiformis*, and "Other"; $r_{Pearson} = 0.87$; n = 10 samples; $p = 0.001$). However, some potentially important differences between the assemblages do exist, as are indicated by a Chi-square analysis of the NISP values for these species ($\chi^2 = 84.7$; df = 9; $p < 0.001$). *Alasmidonta viridis*, *E. dilatata*, *F. flava*, and *A. ligamentina* are more abundant at Sadie's Cave than one would expect by chance, whereas *L. reeviana* and *V. ellipsiformis* are overrepresented at Miller Cave.

Compositional Change

Temporal variation in the relative abundance of mussel species is difficult to assess at Miller Cave because most specimens in the collection are from disturbed or mixed contexts. Only the Early Archaic sample from Trench 1 (levels 6–11) is well-dated and was obtained from unmixed and undisturbed deposits (Table 18). However, the Early Archaic sample is small, consisting of only 25 identifiable shells. Sadie's Cave yielded well-dated samples from the Woodland period (Strata Set A), the Late Archaic period (Strata Set B), the Middle Archaic period (Strata Sets C-D), and the Early Archaic period (Strata Set E; Table 21). However, sample sizes are small in the Middle Archaic and Early Archaic samples.

Despite the small sample sizes, several consistent changes in species composition seem to be represented in the collections (Figure 45). In the Sadie's Cave sequence there is a monotonic decrease in the relative abundance of *Elliptio dilatata* in the Middle Archaic to Woodland samples, while there are monotonic increases in the relative abundances of *Strophitus undulatus* and *Actinonaias ligamentina*. There may also be an increase in species diversity through time; no species occur exclusively in the Middle Archaic deposits (Strata Set C), whereas five species occur exclusively in the Woodland deposits (Strata Set A). Several of these patterns are statistically significant. A Chi-square test of the NISP values of *E. dilatata*, *Venustaconcha ellipsiformis*, and "other" species indicates that significant differences exist among the Miller Cave Early Archaic sample (Trench 1, levels 6–11) and the following Sadie's Cave samples: Middle Archaic (Strata Set

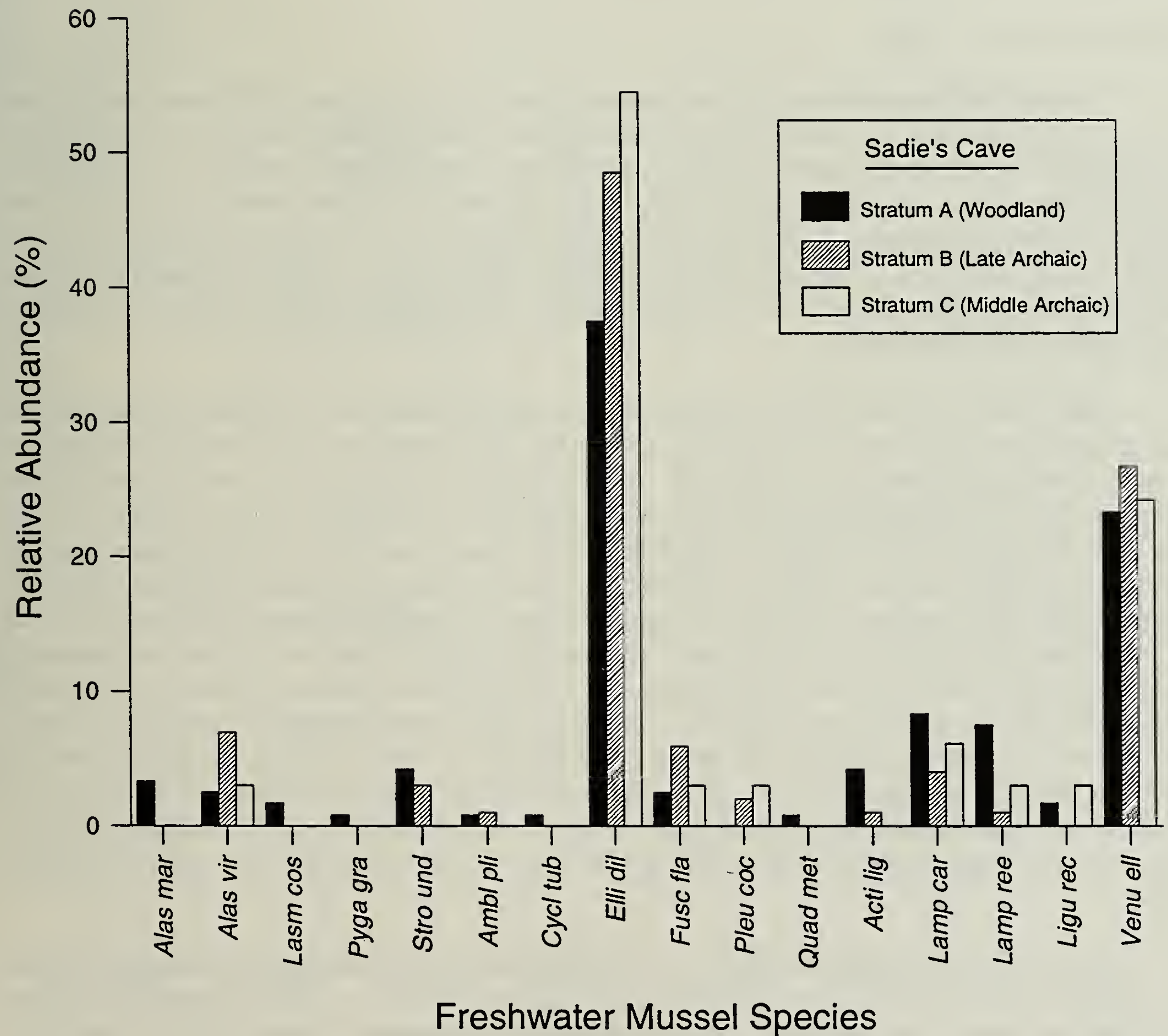


Figure 45. Stratigraphic Variation in the Relative Abundance of Freshwater Mussel Species at Sadie's Cave.

C), Late Archaic (Strata Set B), and Woodland (Strata Set A) (χ^2 = 13.2; df = 6; p = 0.04). *Elliptio dilatata* is underrepresented in the Early Archaic sample (25 percent), rises to its peak abundance in the Middle Archaic sample (55 percent), and then drops off again toward the Woodland sample (37 percent). *Venustaconcha ellipsiformis* is overrepresented in the Early Archaic sample (46 percent) but does not fluctuate significantly in the later samples (23–27 percent). Finally, the pattern of "other" taxa mirrors that of *E. dilatata*; these species drop from the Early Archaic sample (29 percent) to the Middle Archaic sample (21 percent) and then climb toward their peak in the Woodland sample (39 percent). As is indicated below, the latter pattern corresponds directly with variation in the species diversity of the samples.

Paleoenvironmental Model

The approach to paleoenvironmental modeling developed by Warren (1991a) calculates habitat scores for four variables: (1) water-body type (large river, medium river, small river, large creek, small creek, lake); (2) water depth (0–46 dm); (3) current velocity (swift, moderate, slow, standing), and (4) substrate composition (cobble-gravel, gravel, gravel-sand, sand, sand-mud, mud). The scores reflect the percentages of species or individuals in a given mussel assemblage that are adapted to the various categories of the four habitat variables. The scores within each variable do not necessarily sum to 100, however, as the habitat weights for many species are positive in more than one category of a habitat variable.

Miller Cave vs. Sadie's Cave. Habitat scores were calculated for the Miller Cave and Sadie's Cave assemblages based on the percent of species in each assemblage that prefer or tolerate the various habitat types listed above (%TAXA). As is indicated in a plot of the scores (Figure 46), the habitat profiles of the two assemblages are virtually identical. With regard to water-body type, both sites peak on the small-river category (90–91 percent). Fewer than half of the species are adapted to large rivers (42–44 percent), while a majority of species can occupy creeks (68–87 percent). The water-depth profiles are also very similar, indicating that most species prefer shallow water (<1.5 m). The current-velocity profile suggests that most species from the sites prefer swift currents (74–81 percent), although a number of species can tolerate slower currents. Finally, the substrate composition appears to have been primarily a mixture of gravel and sand (87–91 percent). In sum, the paleoenvironmental implications of the two assemblages are very similar. Residents of Miller Cave and Sadie's Cave appear to have collected mussels from a small river with shallow water, a swift current, and a coarse gravelly substrate. These characteristics appear to describe quite well the nearby Big Piney River and point to that stream as the probable source of the prehistoric mussel faunas.

Environmental Change. As noted in the previous section, the species compositions of mussel assemblages changed through time at Miller Cave and Sadie's Cave. Such changes often have environmental causes. To assess the paleoenvironmental implications of compositional changes at the two sites, I calculated habitat scores for the Early Archaic sample from Miller Cave (Trench 1, levels 6–11) and the Middle Archaic (Strata Set C), Late Archaic (Strata Set B), and Woodland (Strata Set A) samples from Sadie's Cave. Habitat scores for two of these—the Sadie's Cave Middle Archaic and Woodland samples—are plotted in Figure 47. Two additional samples are plotted as large-stream and small-stream controls. The large-stream control is a Late Woodland mussel collection from the Feeler site (23MS12), a multicomponent open-air village located near the Gasconade River in Maries County (Reeder 1988). The small-stream control is a pooled collection

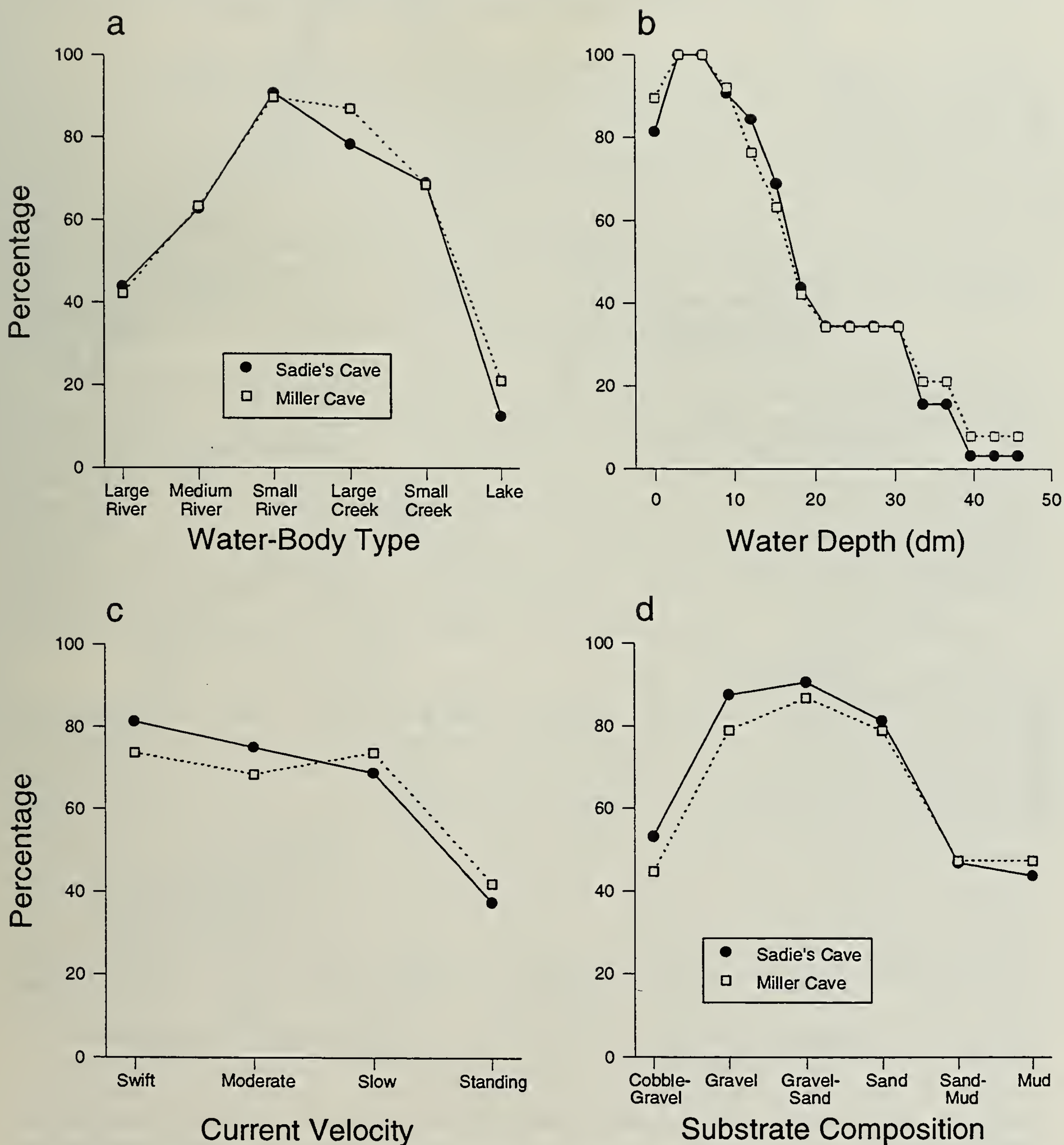


Figure 46. Habitat Scores (%TAXA) of Freshwater Mussel Collections from Sadie's Cave and Miller Cave. Scores denote the percentage of individuals in each assemblage that are common or abundant in each habitat category.

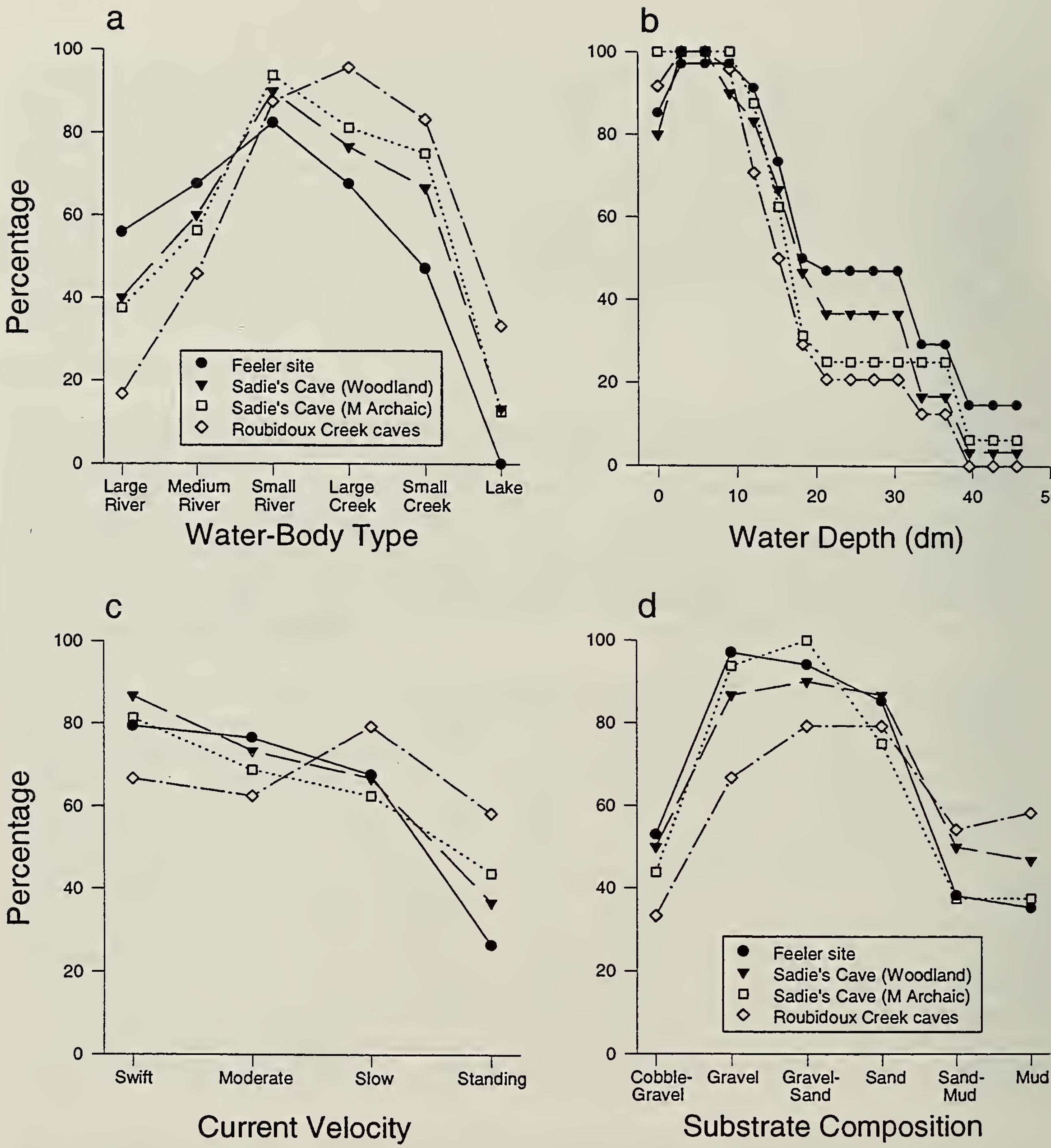


Figure 47. Habitat Scores (%TAXA) of Freshwater Mussel Collections from the northern Ozark Highland, Missouri. The samples plotted are archaeological assemblages located in the Gasconade River system, including the Feeler site (23MS12); Sadie's Cave, Woodland component (23PU235: Stratum A); Sadie's Cave, Middle Archaic component (23PU235: Stratum C); and three caves in the Roubidoux Creek drainage (23PU249; 23PU265: Chuck's Virgin Cave; and 23PU492). Scores denote the percentage of species in each assemblage that are common or abundant in each habitat category.

of mussels from three cave sites (23PU249, 23PU265 and 23PU492) located on the Fort Leonard Wood military reservation near Roubidoux Creek (Warren 1995).

In comparison, the water-body profiles show considerable variation among the four samples (Figure 47). The Feeler sample peaks on the small-river category (82 percent) and has a relatively high proportion of large-river species (56 percent) and a low proportion of small-creek species (47 percent). In contrast, the Roubidoux Creek samples peak on the large-creek category (96 percent); they contain few large-river species (17 percent) and many small-creek species (83 percent). The Sadie's Cave samples are intermediate between these extremes. Although they peak along with Feeler on the small-river category (90–94 percent), they have intermediate proportions of large-river species (37–40 percent) and small-creek species (67–75 percent). The Sadie's Cave patterns are very similar to one another, although the Middle Archaic pattern has a somewhat higher proportion of small-creek species (75 percent) than the Woodland pattern (67 percent).

The water-depth patterns are consistent with the scores for water-body type (Figure 47). The Feeler site has a relatively high proportion of deep-water species (47 percent @ 3 m), while the proportion of deep-water species in the Roubidoux Creek sample is low (21 percent @ 3 m). The Sadie's Cave profiles are again intermediate. Also, the proportions of deep-water species are relatively low for the Middle Archaic sample (25 percent @ 3 m) and higher for the Woodland sample (37 percent @ 3 m). The habitat scores for current velocity and substrate composition show very little difference between the Feeler and Sadie's Cave samples; all three samples indicate swift currents and relatively coarse gravelly to sandy substrates. The Roubidoux Creek sample differs in that it has higher proportions of slow-water and mud-tolerant species.

A geographical framework is sometimes useful for interpreting temporal variation in environmental indicators. To provide a better context for interpreting changes in the Miller Cave and Sadie's Cave mussel faunas, I compiled select habitat scores for the well-dated mussel samples at these sites (Table 23). For reference, scores are also listed for sites located along the Gasconade River, including Onyx Cave in Phelps County (Table 24) and the Feeler site located farther downstream on the Gasconade in Maries County. As above, the pooled sample from Roubidoux Creek caves provides a reference point for small-stream environments. To plot the habitat scores, sites were ordered from left to right by the size of the nearest major stream: Feeler site, Onyx Cave, Sadie's Cave, and Roubidoux Creek caves (Figure 48). The Sadie's Cave components were ordered from Woodland to Middle Archaic because one of the predictions being tested is that the magnitude of the Big Piney River increased from the middle Holocene to the late Holocene. Hence, the habitat indicators should suggest a decrease in stream magnitude from left to right across the graph (Woodland to Middle Archaic). Figure 48 shows that all of the patterns shown increase or decrease monotonically. Proportions of medium-river species increase progressively from the Roubidoux Creek caves to the Feeler site, as do the proportions of species adapted to deep-water habitat (3 m depth). In contrast, the proportions of small-creek species increase from the Feeler site to the Roubidoux Creek caves. It is noteworthy that the Sadie's Cave patterns are consistent with the overall trends. Although the magnitude of change indicated at Sadie's Cave was relatively small from the Middle Archaic to the Woodland periods (3.7–11.7 percent of species), the trends indicated are consistent with the predicted change in the magnitude of the Big Piney River during the Holocene.

Table 23. Freshwater Unionid Mussel Shell from Amateur Excavations at Onyx Cave, Phelps County, Missouri.

Taxon	Sample A[1]	Sample B[2]
Subfamily Anodontinae		
Alasmidonta marginata Say 1818	X	1
Lasmigona costata (Rafinesque 1820)	-	3
Subfamily Ambleminae		
Amblema plicata (Say 1817)	X	1
Cyclonaias tuberculata (Rafinesque 1820)	X	7
Elliptio dilatata (Rafinesque 1820)	X	15
Fusconaia flava (Rafinesque 1820)	X	2
Quadrula metanevra (Rafinesque 1820)	X	2
Quadrula pustulosa (Lea 1831)	X	1
Tritogonia verrucosa (Rafinesque 1820)	X	0
Subfamily Lampsilinae		
Actinonaias ligamentina (Lamarck 1819)	X	17
Lampsilis cardium (Rafinesque 1820)	X	5
Lampsilis reeviana (Lea 1852)	X	1
Ligumia recta (Lamarck 1819)	X	1
Venustaconcha ellipsiformis (Conrad 1836)	X	23
Total	-	79

[1] Selective sample of shell from collection of washed shell displayed along east wall of cave. Donated to the Illinois State Museum by Harry Thillgen (31 January 1995).

[2] Representative (?) sample of shell from unwashed collection of material excavated along east wall of cave (other materials include unmodified bone and ceramic and lithic artifacts). Donated to the Illinois State Museum by Harry Thillgen (31 January 1995).

Table 24. Aquatic Habitat Variation and Change at Archaeological Sites in the Gasconade River System, Missouri.

Stream	Site	Medium River Habitat (% TAXA)	Small Creek Habitat (% TAXA)	Deep Water Habitat (3 m) (% TAXA)	*Actinonaias ligamentina* (% NISP)
Gasconade River	Feeler[1]	67.6	47.1	47.1	35.2
Gasconade River	Onyx Cave[2]	61.5	53.8	42.3	21.5
Little Piney River	Sadie's Cave Woodland[3]	60.0	66.7	36.7	4.2
Little Piney River	Sadie's Cave Late Archaic[3]	60.0	70.0	30.0	1.0
Little Piney River	Sadie's Cave M. Archaic[3]	56.3	75.0	25.0	0.0
Little Piney River	Miller Cave Early Archaic[4]	58.3	50.0	33.3	8.7
Roubidoux Creek	Three caves[5]	45.8	83.3	20.8	0.0

Note: Estimates based on a numerical coding of the habitat preferences of freshwater unionid mussels (Warren 1991a, 1992). Numerical data are the percentages of species in each mussel assemblage adapted to each of three habitat types (Columns 3–5). Column 6 lists the relative abundance of *Actinonaias ligamentina* in each mussel assemblage.

[1] Analysis based on unionid mussel identifications reported by Reeder (1988: 84) (17 species, 105 NISP).

[2] Analysis based on unionid mussel identifications presented in this report (Sample B: 13 species, 79 NISP).

[3] Analysis based on unionid mussel identifications presented in this report (Woodland [Stratum A]: 15 species, 120 NISP; Late Archaic [Stratum B]: 10 species, 101 NISP; Middle Archaic [Stratum C]: 8 species, 33 NISP).

[4] Analysis based on unionid mussel identifications presented in this report (Trench 1 [Zone 2]: 6 species, 23 NISP).

[5] Analysis based on unionid mussel identifications for 3 pooled cave sites at Fort Leonard Wood (23PU249, 23PU265, 23PU492; Warren 1993: 19) (12 species, 79 NISP).

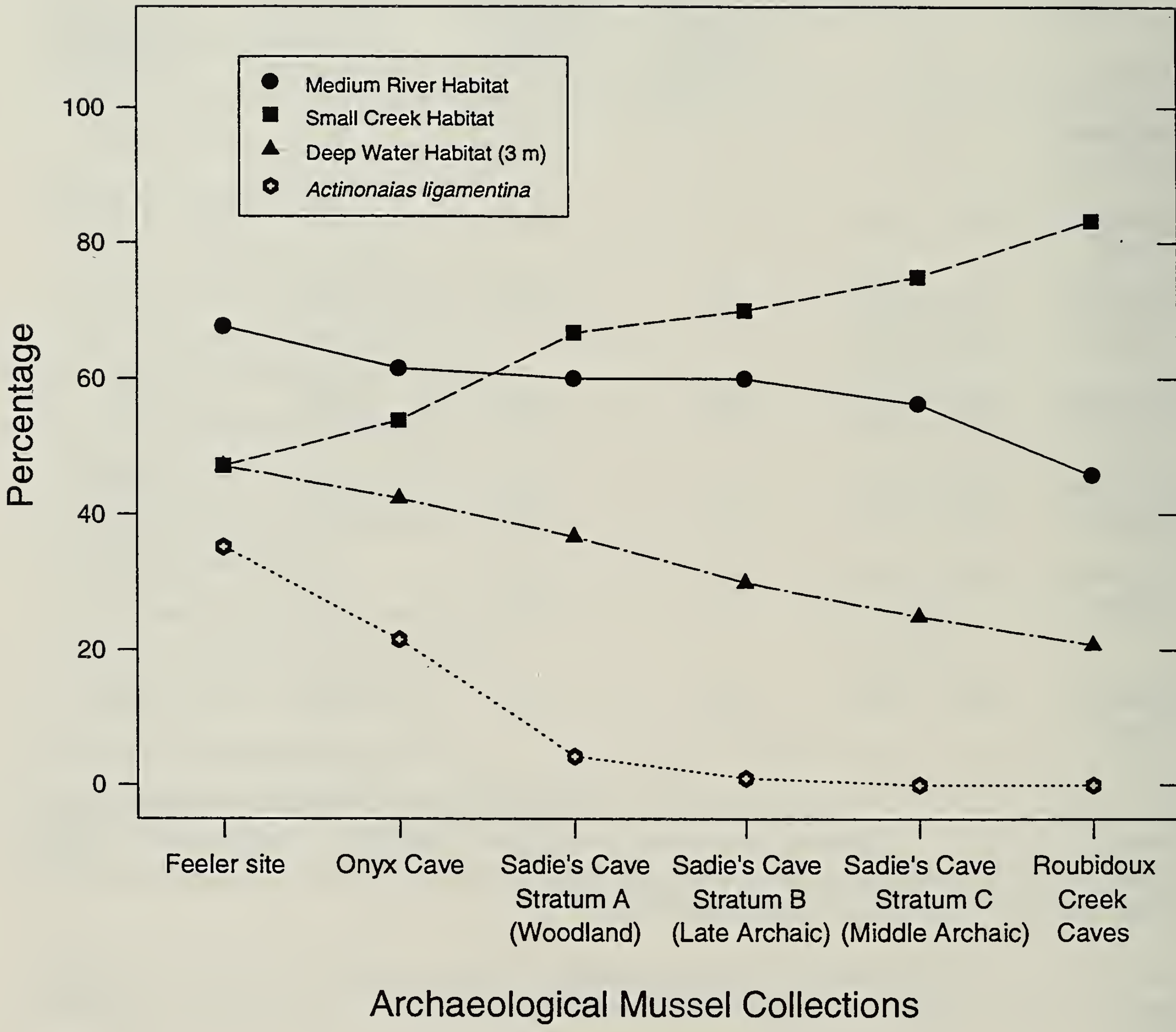


Figure 48. Spatial-temporal Gradient of the Habitat Scores of Freshwater Mussel Collections from the Northern Ozark Highland. The samples grade left-to-right from relatively large streams with deeper water and abundant *Actinonaias ligamentina* to smaller streams with shallower water and no *A. ligamentina*. Three strata at Sadie's Cave (Middle Archaic, Late Archaic, and Woodland strata) are intermediate between Onyx Cave and the Roubidoux Creek caves; variation among them suggests that the magnitude of the Big Piney River changed during the Holocene.

Also plotted in Figure 48 is the relative abundance of the mucket mussel, *Actinonaias ligamentina*, which tends to prefer river habitat and is less common in creeks (Oesch 1984; Warren 1991a). *Actinonaias ligamentina* is absent in the Roubidoux Creek cave samples and in the Middle Archaic stratum at Sadie's Cave, but increases to 1.0 percent in the Late Archaic stratum, 4.2 percent in the Woodland stratum, and thence to 21.5 percent and 35.2 percent, respectively, at Onyx Cave and the Feeler site along the Gasconade River. This pattern confirms the preference of *A. ligamentina* for larger rivers. It also is consistent with the predicted change in the magnitude of the Big Piney River.

Habitat scores for the well-dated Miller Cave and Sadie's Cave mussel samples are also plotted here on a radiocarbon time scale (Figure 49a). From the Early Holocene to the Middle Holocene (8500–6000 B.P.) there was an 8.7 percent decrease in the relative abundance of *Actinonaias ligamentina*, an 8.3 percent decrease in deep-water species, and a 25 percent increase in the relative abundance of small-creek species. Each of these trends was reversed from the Middle Holocene to the Late Holocene (6000–1300 B.P.), when there was a 4.2 percent increase in *A. ligamentina*, an 11.7 percent increase in deep-water species, and an 8.3 percent decrease in small-creek species. These patterns are consistent with the predicted changes in the magnitude of the Big Piney River.

Species Diversity. The species diversity of the Miller Cave and Sadie's Cave mussel samples was calculated using the Simpson diversity index ($1\text{-}D$), which measures the evenness of species abundance values (Magurran 1988). The Simpson index is less sensitive to sample size than many other diversity measures (Magurran 1988:79). However, because of the large size range of the samples (24–120 NISP) it was necessary to test the relationship between diversity and sample size. No significant correlation exists between the two variables ($r_{Pearson} = 0.502$; df $= 2$; $p > 0.1$), indicating that the Miller Cave and Sadie's Cave diversity scores are not adversely affected by sample size.

Long-term changes in species diversity at Miller Cave and Sadie's Cave are plotted in Figure 49b. Diversity decreased from the Early Holocene to the Middle Holocene and then increased into the Late Holocene. This pattern is consistent with the predicted changes in diversity and correlates with the other environmental indicators plotted in the graph.

Discussion and Conclusions

Freshwater mussel shells from Miller and Sadie's caves are probably the remains of a subsistence resource. This is indicated by the high incidences of charred valves in the collections (15–20 percent of NISP) and the rare occurrences of modified shell (0–0.1 percent of NISP). Variation among sites in the rate of charred valves could be due to cultural or temporal differences in the mode of food preparation. The relative importance of mussels in the prehistoric diet is not known, but can be estimated by comparing the food value of mussels with that of other animal remains from the sites (Parmalee and Klippel 1974).

The density of mussel shell increased 30-fold at Sadie's Cave from Early Archaic to Woodland strata. There also was a significant increase through time in the amount of charred shell at Sadie's Cave. These changes could reflect an increase in the dietary importance of mussels or an increase in the intensity of cave occupation, or both. McMillan (1976:217) found a major increase

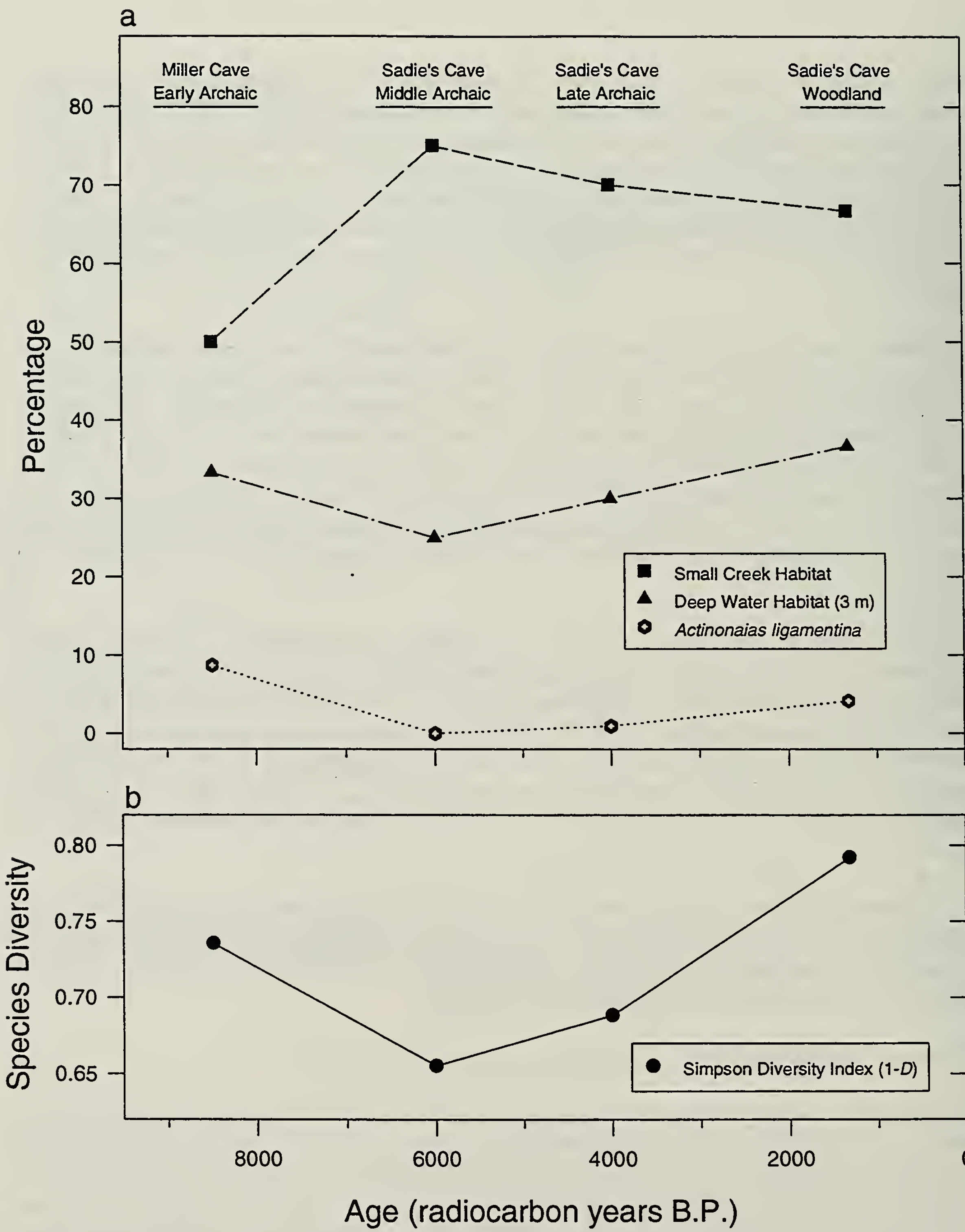


Figure 49. Temporal Change in the (a) Habitat Scores and (b) Diversity of Freshwater Mussel Samples from Miller Cave (Early Archaic stratum) and Sadie's Cave (Middle Archaic, Late Archaic, and Woodland Strata Sets). The small-creek and deep-water curves suggest the Big Piney River carried a relatively high discharge during the Early Holocene (Early Archaic) and Late Holocene (Woodland), but had a relatively low discharge during the Middle Holocene (Middle Archaic).

in the ratio of mussel shell to bone in the long Holocene sequence at Rodgers Shelter in the western Ozark Highland of Missouri, which may reflect a significant change in the dietary importance of mussels. A comparison of shell and bone frequencies is needed to assess any changes in the importance of mussels as a food resource at Sadie's Cave.

Fifteen mussel species have been documented historically in the Big Piney River (Table 22). All but one of these are represented at Miller Cave or Sadie's Cave. The missing species (*Potamilus alatus*) could be a recent immigrant to the river. Or, perhaps more likely, it was relatively uncommon in prehistoric times and it occurs, but has not yet been recovered, in local archaeological samples. Six species that have not been reported historically in the Big Piney River occurred there during prehistoric times: *Alasmidonta marginata*, *A. viridis*, *Amblema plicata*, *Cyclonaias tuberculata*, *Quadrula pustulosa*, and *Tritogonia verrucosa*. All but one of these species have been reported historically from the Gasconade River and it is possible that remnant populations in the Big Piney River have simply been overlooked by modern surveys. The exception, *A. viridis*, has never been reported historically from the Gasconade River system and it may have been extirpated historically.[1]

All but one of the 21 species now documented for the Big Piney River and Roubidoux Creek are members of the extensive Mississippian or Interior Basin mussel fauna (van der Schalie and van der Schalie 1950). The Mississippian fauna occupies most of the Mississippi River basin and also extends northward into the Hudson Bay and Mackenzie River drainages of Canada and southward into the Gulf of Mexico drainages of Texas and Mexico. One species, *Lampsilis reeviana*, is a member of the Ozarkian mussel fauna, which is endemic to the Ozark Plateau region of southern Missouri, northern Arkansas, and eastern Kansas and Oklahoma. The proportions of Ozarkian mussels are highly variable within and among Ozark streams, and in some streams they increase in relative abundance toward the headwaters (Warren 1991b). *Lampsilis reeviana* accounts for 11.4 percent of the mussel assemblage at Miller Cave and 3.8 percent of the assemblage at Sadie's Cave. The cause of this difference is not clear but could be related to change in the local abundance of the species; *L. reeviana* is more abundant in the Woodland stratum at Sadie's Cave (7.5 percent) than in the earlier occupations (1.0–3.0 percent).

The species compositions of Miller Cave and Sadie's Cave are very similar to one another, both qualitatively and in terms of the relative abundance of various species. Assuming that the prehistoric occupants of the caves gathered mussel species in proportion to their occurrence in nature, it appears that *Elliptio dilatata*, *Venustaconcha ellipsiformis*, and *Lampsilis reeviana* were the three most abundant taxa in the lower Big Piney River during the Holocene. However, significant changes did occur in the abundance of species, including shifts in the proportions of *E. dilatata* and *V. ellipsiformis*.

Habitat scores indicate that the mussel assemblages from Miller Cave and Sadie's Cave were gathered prehistorically from the nearby Big Piney River. The Big Piney appears to have been a high-gradient Ozark stream with shallow water, a rapid current, and a coarse gravelly substrate.

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[1] Bernard Sietman of the Missouri Department of Conservation began a new survey of freshwater mussels in the Fort Leonard Wood area in 1993 (Bernard Sietman, personal communication, December 1993). Preliminary results of the survey include the addition of several species to the Big Piney River mussel fauna.

However, this habitat profile shifted somewhat during the Holocene in response to environmental change.

The most dramatic postglacial environmental change in the Midwest involved a mid-Holocene period of relatively warm, dry climate known as the Hypsithermal climatic episode (Deevey and Flint 1957). Judging from changes in fossil pollen, plant macrofossils, faunal assemblages, and sediment profiles, the Hypsithermal was a droughty episode of prairie expansion and dropping lake levels in many areas (Baker et al. 1992; Purdue 1989; Webb et al. 1983, 1993; Wright 1992). Studies at the Rodgers Shelter site in the western Ozark Highland have documented higher rates of hill-slope erosion and a higher incidence of grassland vertebrates in what was historically a primarily forested environment (McMillan and Klippel 1981). Also, Klippel et al. (1978) report significant changes in the species composition of freshwater mussels at Rodgers Shelter, which they attribute to increased discharge in the nearby Pomme de Terre River from Middle Archaic to Woodland times.

The impact of Middle Holocene climate on aquatic environments in the northern Ozark Highland is not known, but the area may have experienced the same warm, dry conditions that appear to have occurred in other parts of the Midwest. This was the basis of my proposition that if drier climatic conditions during the Middle Holocene caused a decrease in the discharge of the Big Piney River, then one would predict several changes in local mussel faunas: (1) decreases in the relative abundance of large-river species (e.g., *Actinonaias ligamentina*), (2) increases in the relative abundance of Ozarkian species (e.g., *Lampsilis reeviana*); (3) decreases in species diversity, and (4) a shift in the habitat preferences of mussel assemblages from small-river to creek environments (Warren 1995). Three of these predictions are confirmed by the mussel faunas from Miller Cave and Sadie's Cave: (1) the relative abundance of *Actinonaias ligamentina* decreased during the Middle Holocene (Figure 49a); (3) species diversity also decreased during the Middle Holocene (Figure 49b); and (4) shifts did occur in the habitat preferences of mussel assemblages, including an increase in the proportion of small-creek species and a decrease in the proportion of deep-water species (Figure 49a). These findings suggest that the discharge of the Big Piney River declined during the Middle Holocene, probably in response to drier climatic conditions.

The failure of *Lampsilis reeviana* to conform to expectations is not clearly understood. Instead of increasing during the Middle Holocene, its percentages fluctuate as follows: 8.3 percent in the Early Archaic (Miller Cave Trench 1), 3.0 percent in the Middle Archaic (Sadie's Cave, Strata Set C), 1.0 percent in the Late Archaic (Sadie's Cave, Strata Set B), and 7.5 percent in the Woodland (Sadie's Cave, Strata Set A). Although *L. reeviana* is an endemic Ozarkian species and Ozarkian species tend to increase in abundance toward the headwaters of the Eleven Point River in southern Missouri (Warren 1991b), it may not be a good indicator of headwater environments along the Big Piney River. Ongoing studies of modern mussel communities in the Big Piney River may resolve this problem.

In a discussion of the species richness and relative abundance of unionid mussels in the eastern United States, Bogan (1990) proposed that mussel communities located in the Interior Basin south of the Pleistocene glacial maximum were compositionally stable during the last 6,000 years of prehistory. To the contrary, this study indicates that the composition and diversity of mussel communities in the northern Ozark Highland were dynamic and changed in response to Holocene climatic fluctuations. Prehistoric compositional changes have also been documented in the central Great Plains (Warren 1992b), in the western Ozark Highland (Klippel et al. 1978), near the Ohio

River (Warren 1994), and along the Tennessee River (Warren 1975). Many species of unionid mussels are sensitive to environmental conditions, and it should not be surprising that mussel communities responded to environmental changes during the Holocene. Mussel assemblages from archaeological sites are useful sources of data on the dynamics of past aquatic environments.

Analysis of Faunal Remains

Faunal remains from Sadie's Cave were analyzed using the comparative skeletal collections of the Department of Anthropology, University of Illinois at Urbana-Champaign and the Illinois State Museum. All elements were identified to the most exclusive taxon possible. Additional data collected include the side of the element, when applicable, whether it had been gnawed by rodents or carnivores, whether burning was evident, and whether it had been humanly modified. The assemblage consists of material obtained from both screening test unit soils through 6.4-mm mesh hardware cloth and from the light and heavy fractions of the flotation samples. The initial analytic units consist of the excavation levels, levels grouped by strata, or features, within each of the excavation units. Much of the data were then collapsed into six macrostratigraphic units that are temporally linked and cross-cut the individual excavation units. Overviews of the excavation unit assemblages are presented first, followed by an analysis of the macrostratigraphic assemblages.

Excavation Unit Assemblages

A total of 4,729 elements from a surface collection and the excavation units was examined from Sadie's Cave (Table 25). The remains were most numerous in Test Units 4/5 and 2/6, and least numerous within Test Unit 7 and from the surface collection. Within the assemblage as a whole, 68 percent could be identified only as vertebrate, with the remaining 32 percent identified to various taxonomic levels within the fish, amphibian, reptile, bird, and mammal classes. Most common are mammals, comprising 21 percent of the assemblage. Birds and fish are present in approximately the same numbers, while reptiles and amphibians are poorly represented at Sadie's Cave.

Surface Assemblage. Smallest of all the individual provenience assemblages, only 41 elements were collected from the surface. This total minimally represents nine species, mainly comprised of mammals. Many of the mammal species, such as cottontail rabbit (n=3), striped skunk (n=1), bats (n=1), and rodents (n=1) could represent modern, incidental additions to the assemblage. Additional mammals identified in this assemblage include unidentified large mammals (n=8), unidentified small mammals (n=3), muskrat (n=1), white-tailed deer (n=9), woodchuck (n=2), and unidentified medium mammals (n=2). Bird remains include unidentified bird (n=6) and an unidentified owl element (n=1). Reptilian elements include unidentified turtle (n=1) and pond turtle (n=1). The only fish from the surface is a single redhorse element. Not surprisingly, 41 percent (n=17) of the elements in this assemblage evidence either rodent or carnivore gnawing, while no elements were burned.

Test Unit 2/6. A total of 1,236 elements from 10 analytical units was recovered in this test unit (Table 26). This figure represents the second highest number of elements of all the excavation unit assemblages from Sadie's Cave. Of this total, 59 percent were identified as vertebrate. Of the remainder, mammals were the most common class, and included a number of taxa normally found

Table 25. Composition of the Faunal Assemblage of Sadie's Cave.

Class	Number of Identified Elements	Percent of Identified Elements	Number of Unidentified Elements	Total	Percent of All Elements
Vertebrate	0	0	3,214	3,214	68
Mammals	218	58	753	971	21
Birds	31	8	190	221	5
Fish	73	19	135	208	4
Herptiles*	53	14	62	115	2
Total	**375**	**99**	**4,354**	**4,729**	**100**

in cave environments such as bats and rodents. Unidentified large mammal and deer elements, though, constituted the largest segment of mammals. The identified bird elements include perching/song birds, grackle, turkey, coot, and unidentified owl. Turkey was found only in Feature 2 of Test Unit 2/6. Fish species include sunfish, gar, suckers, and catfish. Lastly, reptiles and amphibians consist of mud/musk, pond and box turtles, copperhead snake, and toad elements. Carnivore or rodent gnaw marks were found on only seven elements, most from either the upper excavation levels or Feature 2. Burning was identified on 204 elements, although almost half this total was from Feature 112. Numerous burned elements also were found in Feature 2 and the initial three strata in this excavation unit.

Test Unit 3. With 966 elements, this excavation unit has the third-most numerous assemblage of all the excavation units, comprising 20 percent of the entire site assemblage (Table 27). A minimum of 15 species was identified in the Test Unit 3 assemblage. Approximately 77 percent of this assemblage was identified as vertebrate. Of the elements identified to a particular class, mammal is most common, followed by fish, bird, reptiles, and amphibians. The mammal assemblage is heavily weighted towards unidentified large mammal and deer elements, with smaller numbers of bat, ground squirrel, mice, and rat elements present. Fish species include gar, suckers, catfish, and sunfish, while only perching/song bird elements were identified in the bird assemblage. The reptiles and amphibians consist of unidentified turtle and copperhead snake. Only 13 elements had carnivore or rodent gnawing, most of which were from the first stratum. Burning was identified on 216 elements, over half of which were from Stratum 1.

Test Unit 4/5. Faunal remains from this test unit represent the single largest assemblage from the excavation units at Sadie's Cave, comprising 49 percent of the entire site assemblage (Table 28). At least 25 species were identified in the Test Unit 4/5 assemblage. Slightly over 72 percent of this assemblage was identified as vertebrate; of the remainder, mammals are most numerous, followed by bird, fish, reptiles, and amphibians. While unidentified large mammal and deer elements are

Table 26. Distribution of Faunal Remains within Test Unit 2/6.

	Provenience									
Taxon	S1	S2	S3	L4	S5	S6	S7	F112	F104	F2
Unidentified Vertebrate	25	137	205	6	136	5	12	83	4	113
Lepisosteus sp. (gar)	0	0	0	0	2	0	1	0	0	1
Moxostoma sp. (redhorse)	0	0	0	0	0	0	0	0	0	4
Catostomidae (sucker)	0	0	1	0	0	0	0	0	0	0
Ictalurus sp. (catfish)	0	0	0	0	1	0	0	0	0	1
Centrarchidae (sunfish)	0	1	1	0	1	0	0	0	0	3
Unidentified Fish	2	8	14	0	15	0	0	3	1	16
Bufo sp. (toad)	0	0	0	0	0	0	0	0	0	1
Unidentified Amphibian	0	6	5	0	0	0	0	0	0	8
Kinosternidae (mud/musk turtle)	0	0	1	0	0	0	0	0	0	0
Terrapene sp. (box turtle)	0	0	2	0	0	0	0	0	0	0
Chrysemys sp. (pond turtle)	0	0	0	0	0	0	0	0	0	1
Unidentified Turtle	0	1	3	0	0	0	0	0	0	1
Ancistrodon contortrix (copperhead)	1	0	1	0	0	0	0	0	0	4
Unidentified Reptile	0	0	2	0	4	0	0	0	0	4

Table 26. Concluded.

	Provenience									
Taxon	S1	S2	S3	L4	S5	S6	S7	F112	F104	F2
Meleagris gallopavo (turkey)	0	0	0	0	0	0	0	0	0	1
Fulica americana (coot)	0	0	0	0	1	0	0	0	0	0
Strigiformes (owl)	0	0	0	0	1	0	0	0	0	0
Quisquilus quisquila (grackle)	0	0	0	0	1	0	0	0	0	0
Passeriformes (song/perching bird)	0	0	1	0	0	0	0	0	0	2
Unidentified Bird	4	4	13	3	20	2	1	1	1	25
Small Bat	0	1	0	0	0	0	0	0	0	1
Large Bat	0	0	0	0	1	1	0	0	0	1
Chiroptera (bat)	1	8	6	1	3	0	0	0	0	2
Sylvilagus floridanus (eastern cottontail rabbit)	0	0	2	0	0	0	0	0	0	3
Tamias striatus (eastern chipmunk)	0	0	0	0	1	0	0	0	0	0
Marmota monax (woodchuck)	0	0	0	0	2	0	0	0	0	0
Sciurus niger (fox squirrel)	0	0	1	0	0	0	0	0	0	0
Neotoma floridana (eastern woodrat)	0	1	0	0	1	0	0	0	0	0
Microtus sp. (vole)	0	0	3	0	1	0	0	0	0	0
Ondatra zibethica (muskrat)	0	0	0	0	0	0	0	1	0	0
Unidentified Rodent	0	1	1	1	0	0	0	0	0	1
Canis sp. (canids)	0	0	0	0	0	0	0	0	0	1
Odocoileus virginianus (white-tailed deer)	5	2	4	0	0	0	0	1	0	5
Unidentified Small Mammal	0	1	12	0	10	1	1	0	0	5
Unidentified Medium Mammal	0	4	9	0	0	0	0	0	0	1
Unidentified Large Mammal	8	12	18	0	15	1	1	1	2	84
Unidentified Mammal	9	1	22	0	4	1	0	14	3	4

Table 27. Distribution of Faunal Remains within Test Unit 3.

Taxon	S1	L3	S2	S3	L7	F4	F5	Mixed
Unidentified Vertebrate	239	23	338	10	45	70	23	0
Lepisosteus sp. (gar)	0	0	1	0	0	0	0	0
Moxostoma sp. (redhorse)	1	0	0	0	0	0	0	0
Catostomidae (sucker)	1	0	2	0	0	0	0	0
Ictalurus sp. (catfish)	1	0	0	0	0	0	0	0
Centrarchidae (sunfish)	1	0	0	0	1	0	0	0
Unidentified Fish	1	0	19	0	1	2	0	0
Unidentified Amphibian	1	1	3	0	0	0	0	0
Chrysemys sp. (pond turtle)	0	0	1	0	0	0	0	0
Unidentified Turtle	1	0	2	0	0	0	0	0
Ancistrodon contortrix (copperhead)	0	0	1	0	0	0	0	0
Unidentified Reptile	0	0	4	0	0	0	0	0
Passeriformes (song/perching bird)	1	0	0	0	0	0	0	0
Unidentified Bird	7	1	14	1	0	0	4	2
Small Bat	0	0	1	0	0	0	0	0
Chiroptera (bat)	0	1	0	0	0	0	1	0
Tamias striatus (eastern chipmunk)	0	0	1	0	0	0	0	0
Spermophilus sp. (groundsquirrel)	0	0	1	0	0	0	0	0
Peromyscus sp. (mouse)	1	0	0	0	0	0	0	0
Neotoma floridana (eastern woodrat)	0	0	-1	0	0	1	0	0
Microtus sp. (vole)	0	0	0	0	1	0	0	0
Unidentified Rodent	1	1	2	0	0	0	0	0
Odocoileus virginianus (white-tailed deer)	4	0	2	0	0	1	0	0
Unidentified Small Mammal	3	0	14	0	1	2	1	1
Unidentified Medium Mammal	2	0	2	1	0	0	0	0
Unidentified Large Mammal	34	2	26	2	0	17	1	0
Unidentified Mammal	1	7	4	2	0	0	0	0

Table 28. Distribution of Faunal Remains within Test Unit 4/5.

Taxon	S1	S2	S2a	S3–5	L4	L11	S7	S8	F6	F9	F101	F8	F119	F16	F3
Unidentified Vertebrate	3	11	24	263	13	81	276	432	26	30	25	37	17	53	21
Lepisosteus sp. (gar)	0	0	0	15	0	0	0	0	0	0	0	0	0	0	1
Catostomidae (sucker)	1	0	1	11	0	0	0	0	0	0	0	0	0	0	0
Ictalurus sp. (catfish)	0	1	0	0	0	0	1	2	0	0	0	0	0	0	0
Centrarchidae (sunfish)	0	0	3	3	0	0	1	0	0	0	0	0	0	0	0
Unidentified Fish	1	0	3	25	2	0	5	5	0	1	0	3	1	1	0
Bufo sp. (toad)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Unidentified Amphibian	0	0	0	0	0	2	2	3	1	1	1	1	0	1	1
Terrapene sp. (box turtle)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Chrysemys sp. (pond turtle)	0	0	0	1	0	0	1	0	0	1	0	1	0	0	0
Trionyx sp. (softshell turtle)	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Unidentified Turtle	1	1	0	1	1	1	0	0	0	0	0	0	0	1	1
Ancistrodon contortrix (copperhead snake)	0	0	0	1	0	2	2	0	0	0	0	0	0	1	0
Unidentified Reptile	0	0	0	3	0	0	3	3	0	0	0	0	0	2	0
Unid. Reptile/Amphibian	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Podilymbus podiceps (pied-billed grebe)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Anas sp. (duck)	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Fulica americana (coot)	0	0	0	1	0	0	1	0	0	0	0	0	0	0	2
Passeriformes (song/perching bird)	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Unidentified Bird	1	1	4	12	3	12	19	12	2	3	0	3	5	2	4

Table 28. Concluded.

Taxon	S1	S2	S2a	S3–5	L4	L11	S7	S8	F6	F9	F101	F8	F119	F16	F3
Scalopus aquaticus															
(eastern mole)	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0
Small Bat	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
Large Bat	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Chiroptera (bat)	1	0	0	8	1	4	6	3	0	0	0	1	0	1	0
Sylvilagus floridanus															
(eastern cottontail rabbit)	0	0	0	4	0	0	0	0	0	0	2	0	0	0	0
Marmota monax															
(woodchuck)	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Spermophilus sp.															
(groundsquirrel)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Sciurus sp. (squirrel)	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Peromyscus sp. (mouse)	0	0	0	1	0	1	3	0	0	0	0	0	0	0	0
Neotoma floridana															
(Eastern woodrat)	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Microtus sp. (vole)	0	0	0	1	0	0	6	0	0	1	0	0	0	0	1
Ondatra zibethica (muskrat)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Unidentified Rodent	0	0	0	3	0	0	2	10	0	0	0	0	0	0	0
Odocoileus virginianus															
(white-tailed deer)	1	4	3	11	1	1	1	0	0	0	1	2	0	0	2
Unidentified Small Mammal	1	0	1	29	0	5	30	17	3	7	0	3	1	4	5
Unidentified Medium Mammal	1	0	2	4	0	0	1	0	1	1	0	0	0	0	0
Unidentified Large Mammal	2	18	12	48	4	4	4	10	1	4	1	1	1	6	3
Unidentified Mammal	0	1	0	26	0	7	2	10	1	18	0	3	1	5	8

well-represented, smaller species such as bats, cottontail rabbit, moles, mice, rats, and others are, as a whole, numerically superior. A rather diverse array of bird species was identified in this test unit assemblage, including pied-billed grebe, coot, unidentified duck, and perching/song birds. Fish species consist of suckers, catfish, gar, and sunfish. A number of reptile and amphibian species were identified, including pond, box and softshell turtles, copperhead snake and toads. Only five elements from this assemblage were gnawed by rodents or carnivores, while 292 were burned. Many of the burned elements are from Strata 3–5 and Stratum 8.

Test Unit 7. Aside from the surface collection, the Test Unit 7 assemblage is the smallest of all assemblages from Sadie's Cave, accounting for just three percent of the site total (Table 29). Not surprisingly, few species were identified, with a minimum of 12 species present in this assemblage. In contrast to the other test unit assemblages, a relatively large portion of elements from this assemblage was identified to particular classes, with only 41 percent being classified as vertebrate. Of the identified elements, mammals are most common, followed by birds, fish, reptiles, and amphibians. Unidentified large mammal and deer elements dominate the mammal assemblage with fewer small species identified. A single element of a possible dog was found in Stratum 1 of this unit, the only occurrence of this taxa in the site assemblage. Perching/song bird was the only bird taxon identified, while the fish consisted of suckers and sunfish. The reptiles and amphibians are represented by box and pond turtles, copperhead snakes and unidentified amphibians. Only eight elements from Test Unit 7 had been rodent or carnivore gnawed and 18 elements were burned. All of the burned elements are from the initial two excavation levels.

Strata Set Analysis

Six strata sets, correlated with specific temporal ranges, have been defined for the Sadie's Cave deposits. The strata consist of Stratum A–Middle to Late Woodland, Stratum B–Late Archaic, Stratum C–late Middle Archaic, Stratum D–early Middle Archaic, Stratum E–Early Archaic and Stratum F–possibly pre-Early Archaic. Of the total site assemblage, 4,085 elements could be assigned to one of these six strata sets. The remainder of the elements, documented in the discussion above, could not be assigned to one of these strata sets.

The number of specimens assigned to each of the strata sets differs widely, with Strata Set B, dating to the Late Archaic period, having the most specimens—42 percent of the entire strata set assemblage. Strata sets A, C and E are all similar in number, with each contributing between 15 and 20 percent of the entire strata set assemblage. Strata sets D and F are the smallest, accounting for five percent and less than one percent, respectively. The minimum number of species identified within these assemblages ranges from a low of five in Strata Set F, the smallest of the sets, to a high of 21, in Strata Set B, the largest of the assemblages.

Strata Set A. The Set A assemblage is the second largest of the six strata set assemblages, consisting of 821 elements or 20 percent of the entire Strata Set assemblage (Table 30). A minimum of 15 species was identified in this assemblage, which dates to the Middle to Late Woodland periods. As with most assemblages from Sadie's Cave, elements identified as vertebrate dominate, comprising 67 percent of the entire assemblage. Mammals are most numerous, followed by birds, fish, reptiles, and amphibians. Larger animal elements, either deer or unidentified large mammal, are most numerous within the mammal class. Medium-sized mammals are less numerous, although a possible dog element is included in this assemblage. Finally, a number of small mammal species are present,

Table 29. Distribution of Faunal Remains within Test Unit 7.

Taxon	S1	L2	S3	S4	S5
Unidentified Vertebrate	13	9	29	16	1
Moxostoma sp. (redhorse)	0	1	0	0	0
Micropterus sp. (bass)	1	0	0	0	0
Unidentified Fish	3	1	1	1	0
Unidentified Amphibian	0	1	0	0	0
Terrapene sp. (box turtle)	0	1	0	0	0
Chrysemys sp. (pond turtle)	0	3	0	0	0
Unidentified Turtle	0	1	1	0	0
Ancistrodon contortrix (copperhead snake)	0	1	0	0	0
Passeriformes (song/perching bird)	0	0	1	0	0
Unidentified Bird	3	1	2	2	0
Chiroptera (bat)	1	1	1	2	0
Sylvilagus floridanus (eastern cottontail rabbit)	1	0	0	0	0
Neotoma floridana (eastern woodrat)	0	0	0	1	0
Canis sp. (canid)	1	0	0	0	0
Odocoileus virginianus (white-tailed deer)	4	3	1	0	0
Unidentified Small Mammal	2	1	0	0	1
Unidentified Medium Mammal	2	0	1	0	0
Unidentified Large Mammal	6	29	7	2	0
Unidentified Mammal	2	0	3	0	0

including cottontail rabbit, moles, mice, rats, bats, and muskrat. Bird elements are unidentified except for a single perching/song bird element. Fish include elements of the sunfish, sucker and gar families. The reptiles consist of pond turtle and copperhead snake, while no amphibian elements could be identified below class level. This suite of species identified in Set A indicates that species inhabiting the Big Piney River and its floodplain were being exploited in addition to those species more commonly found in the uplands above Sadie's Cave. Numerous other species, such as bats, moles, mice, and rats are probably incidental to the cave itself.

Table 30. Distribution of Taxa by Strata.

Taxon	Stratum A	B	C	D	E	F
Unidentified Vertebrate	544	1,224	481	136	523	5
Lepisosteus sp. (gar)	0	16	0	2	1	0
Moxostoma sp. (redhorse)	1	0	0	0	0	0
Catostomidae (suckers)	2	2	1	0	0	0
Ictalurus sp. (catfish)	2	0	1	1	2	0
Micropterus sp. (bass)	1	0	0	0	0	0
Centrarchidae (sunfish)	4	5	2	1	1	0
Unidentified Fish	20	54	19	15	8	0
Bufo sp. (toad)	0	1	0	0	0	0
Unidentified Amphibian	3	22	7	0	3	0
Kinosternidae (mud/musk turtle)	0	0	1	0	0	0
Terrapene sp. (box turtle)	0	0	3	0	0	0
Chrysemys sp. (pond turtle)	1	2	1	0	0	0
Trionyx sp. (softshell turtle)	0	1	1	0	0	0
Unidentified Turtle	3	5	4	0	0	0
Ancistrodon contortrix (copperhead snake)	1	2	3	0	0	0
Unidentified Reptile	0	7	5	4	3	0
Unidentified Reptile/Amphibian	0	2	0	0	0	0
Podilymbus podiceps (pied-billed grebe)	0	0	1	0	0	0
Anas sp. (duck)	0	1	1	0	0	0
Fulica americana (coot)	0	1	1	1	0	0
Strigiformes (owl)	0	0	0	1	0	0
Quisquilas quisquila (grackle)	0	0	0	1	0	0
Passeriformes (song/perching bird)	1	3	1	0	0	0
Unidentified Bird	33	42	32	20	20	2

Table 30. Concluded.

Taxon	Stratum A	B	C	D	E	F
Scalopus aquaticus (eastern mole)	1	3	0	0	0	0
Small Bat	0	2	1	0	1	0
Large Bat	0	0	0	1	2	0
Chiroptera (bat)	4	18	12	3	5	0
Sylvilagus floridanus (eastern cottontail rabbit)	2	4	2	0	0	0
Tamias striatus (eastern chipmunk)	0	1	0	1	0	0
Marmota monax (woodchuck)	0	0	0	2	2	0
Spermophilus sp. (groundsquirrel)	0	1	1	0	0	0
Sciurus niger (fox squirrel)	0	0	1	0	0	0
Sciurus sp. (squirrel)	0	2	0	0	0	0
Peromyscus sp. (mouse)	1	1	3	0	0	0
Neotoma floridana (eastern woodrat)	1	2	0	1	2	0
Microtus sp. (vole)	0	3	9	1	1	0
Ondatra zibethica (muskrat)	1	1	0	0	0	0
Unidentified Rodent	0	6	3	0	10	1
Canis sp. (canids)	1	0	0	0	0	0
Odocoileus virginianus (white-tailed deer)	26	16	5	0	0	0
Unidentified Small Mammal	15	59	42	10	21	1
Unidentified Medium Mammal	8	14	10	0	0	0
Unidentified Large Mammal	104	106	22	15	14	1
Unidentified Mammal	31	75	24	4	11	1

Strata Set B. Most numerous of all the strata sets, this assemblage dating to the Late Archaic period has 42 percent of all strata set elements (Table 30). Slightly over 71 percent of the Strata Set B assemblage was identified as vertebrate. Of the remaining elements, mammals are most common, followed by fish, bird, reptile, and amphibian. Large mammals comprise about one-third of all identified mammal elements. A more diverse range of small mammal species was identified in this assemblage, including the eastern woodrat, mice, cottontail rabbit, moles, bats, striped groundsquirrel, squirrels, and muskrat. Fish, while numerically the second-most commonly identified class, consist only of sunfish, gar and sucker elements. The bird assemblage includes elements identified as perching/song bird, coots and unidentified duck. Reptiles consist of pond and softshell turtles as well as copperhead snake, while a single amphibian element has been identified

as toad. This assemblage appears to document the use of the Big Piney River and its adjacent floodplain as well as the uplands located above the site.

Strata Set C. This set, dating to the late Middle Archaic period, is the third largest assemblage, consisting of 17 percent of all elements that could be assigned to particular strata sets (Table 30). Elements identified as vertebrate comprise 69 percent of this assemblage. Of those elements identified to class, mammals are most numerous, followed by birds, reptiles, amphibians, and finally fish. Large mammal elements are not particularly numerous in this assemblage, due to an increase in small mammal elements such as bats, mice and cottontail rabbit. Identified birds include coots, pied-billed grebes, unidentified duck, and perching/song birds. Reptiles include a wide variety of turtles, such as pond, softshell, mud/musk, and box, as well as copperhead snake. Fish species consist of sunfish, catfish and suckers. The assemblage appears to have either decreased emphasis on large mammals or an increase in the deposition of smaller mammals, of which some of the species are incidental to cave habitats. There also appears to be an increase in the number of turtle species and aquatic bird species in this assemblage. These trends may indicate a slightly greater emphasis on the exploitation of animals associated with aquatic environments during this time period.

Strata Set D. This early Middle Archaic assemblage is the second smallest of all the strata sets, accounting for only five percent of the entire strata set assemblage (Table 30). A total of 62 percent of all Strata Set D elements was identified as vertebrate. Aside from those elements, mammals are most numerous, followed by birds, fish, reptiles, and amphibians. Large mammal elements are fairly well-represented, although none could be identified to a particular species. Smaller animal species identified in this assemblage include striped groundsquirrel, woodchuck, eastern woodrat, mice, and bats. Bird elements identified to particular taxa are unidentified owl, grackle and coot. No reptile or amphibian elements were identified below class level. On the whole, this assemblage has the highest number of identified elements of aquatic taxa of all the strata sets, although that pattern could be due to sampling and the small size of the assemblage.

Strata Set E. This Early Archaic assemblage is the fourth largest of all the strata sets, comprising 15 percent of all the material associated with particular strata sets (Table 30). It also has the highest rate, at 83 percent, of elements identified as vertebrate. Of the remainder, mammals are most numerous followed by birds, fish, reptiles, and amphibians. Small mammals dominate that class, with larger mammals being poorly represented. Fish species include gar and catfish. No bird or reptile and amphibian elements were identified below class level.

Strata Set F. This is the smallest of all the strata set assemblages, consisting of only 10 elements, with half being identified as vertebrate (Table 30). The other five elements include mammal and bird, none of which could be identified to a particular taxon.

Discussion

The faunal remains collected from Sadie's Cave provide a data base that can be used to address a number of pertinent research issues, most importantly dealing with temporal trends in exploitation strategies and environmental change. The information obtained from this research also can be compared with other sites in the Fort Leonard Wood region. As such, this discussion will center on comparisons of the assemblages from the six strata that have been correlated with specific

temporal components at Sadie's Cave. Strata Set F, the surface materials and certain individual proveniences are dropped from this discussion due to their lack of association with particular components. In analyzing the faunal assemblages in this manner, though, an understanding of sample characteristics is crucial to the interpretation of results.

Grayson (1984) has summarized research on what is perhaps the most salient issue regarding the comparative use of faunal assemblages in archaeological subsistence or environmental analyses. The sample size effect, which biases minimum number of species comparisons between samples with large differences in number of specimens, is perhaps the most common analytical problem encountered. In effect, when the samples being compared are numerically disparate, differences in the minimum number of species between the samples are suspect based on a positive correlation between sample size and number of species. Since the relationship between these two variables is asymptotic, a comparison between large assemblages may be valid. In order to test for this problem with the Sadie's Cave strata-based assemblages, a Pearson Correlation was performed. A positive correlation of 0.823 between sample sizes and number of species was obtained, suggesting that much of the information concerning species diversity in the Sadie's Cave assemblages is due to sample sizes. Conclusions based solely on increasing or decreasing sample sizes are thus suspect in this group of assemblages. With this caveat in mind, the following discussion will center on identifying changes in faunal exploitation, the effect of the Hypsithermal Interval and a comparison of the Sadie's Cave assemblages with other sites in the region.

Faunal Exploitation Strategies. Considering the wide span of time represented by the Sadie's Cave assemblages, faunal exploitation patterns remain generally similar. Several subtle trends can be identified, although their validity remains to be tested through additional excavations. Fish use appears to increase during the Middle Archaic period only to drop off during the Middle-Late Woodland period. Fish exploitation centers on species common in the nearby Big Piney River (Pflieger 1975), such as gar (most probably longnose gar), sunfish, catfish, and probably a number of redhorse sucker species. Gar and sunfish remains are most common in the Late Archaic component, while species diversity is similar throughout the six components. A similar trend is evident for reptiles and amphibians, mainly reflecting the use of turtles. Turtle use, especially related to the use of aquatic species such as pond turtles and softshell turtles, appears to increase from the late Middle Archaic period onward. Interestingly, box turtle, a more terrestrial species, is only found in the late Middle Archaic assemblage. Bird use, alternatively, appears to remain relatively stable with the exception of an increase during the Middle Archaic period. Species exploited include coots, pied-billed grebes and ducks, as well as perching/song birds and owls. Turkeys were exploited, although none of the remains were associated with dated proveniences. Species such as ducks, coots and pied-billed grebes may represent seasonal migrants to the Pulaski County area, and their relative paucity would be indicative of the position of Sadie's Cave away from a major migratory waterfowl flyway. Finally, mammal exploitation appears to remain stable to slightly increasing during the Archaic period, with a larger increase occurring in the Middle-Late Woodland period. A large proportion of the mammal assemblages could be classified as incidental to caves, including animals such as bats, mice, voles, woodrat, and moles. Other species are more problematic, such as groundsquirrels, rabbits and squirrels. Certain species—such as white-tailed deer, muskrat, possibly dog, and woodchuck—are clearly introduced into the cave deposits. Both number of mammal elements and number of species increase after the early Middle Archaic period. The number of deer elements present also increases with time after the early Middle Archaic period.

In general, faunal exploitation by the inhabitant's of Sadie's Cave was constrained by the immediate environment. Mammals were most probably always the most important group of species, although fish use increased during the Middle and Late Archaic periods. Mammal exploitation centered on white-tailed deer, with smaller mammals such as woodchuck, muskrat and rabbit also contributing to the diet. The use of small mammals such as woodrat, mice and voles cannot be discounted. Other groups such as birds and turtles also were used, but once again these groups appear to be more subsidiary to mammals and may have been taken on an opportunistic basis.

Effects of the Hypsithermal Interval. The Hypsithermal Interval during the Middle Archaic period is often associated with a decrease in rain and an increase in temperature, resulting in the spread of prairie habitats. This in turn may have led to a prehistoric settlement pattern focused on river valleys. The effects of such a drastic climatic and resultant vegetational change should be evident in the taxa exploited by human populations and the emphasis placed on particular groups of taxa. If prairie habitats expanded, animal species adapted to such environments should become common in Middle Archaic assemblages. In addition, if populations became more concentrated near rivers or became more dependent on species that inhabit rivers or river valleys, increased numbers of fish, turtle, amphibian, and aquatic mammals should be present in Middle Archaic assemblages. Regarding the Sadie's Cave assemblage, most of the identified taxa are found throughout the Midwest and Great Plains. Certain taxa are more common to the east such as eastern cottontail rabbit, eastern mole, eastern chipmunk and eastern woodrat, which are found in Middle Archaic and later deposits. Interestingly, a possible groundsquirrel element, more common in a Plains/Grassland setting, was found only in the Middle Archaic assemblage. The contribution of aquatic species (e.g., fish, certain reptiles and amphibians, and aquatic mammals) increased during the Middle Archaic period but changed little in the Late Archaic period. An aquatic mammal such as the muskrat, in fact, is absent from Middle Archaic assemblages while present in the Late Archaic and Middle-Late Woodland assemblages.

It is apparent that the Sadie's Cave faunal assemblage is poorly suited to addressing this issue. While use of aquatic taxa is greater than that evidenced in the Early Archaic assemblage, it is similar to that of the post-Hypsithermal Late Archaic assemblage. As well, few or perhaps no grassland species are present in the assemblage. It may be suggested, at least with regards to faunal exploitation strategies, that the Hypsithermal had little impact on the species exploited by the inhabitants of Sadie's Cave. Given the present data base, at most, the Hypsithermal may have caused increased dependence on, or alternatively, less use of, particular species.

Intersite Regional Comparisons. Previous excavations at sites located within Fort Leonard Wood have yielded small assemblages that are poorly suited for this type of comparison. Perhaps the largest, and best-documented assemblage is from Tick Creek Cave in Phelps County, located to the northeast of Sadie's Cave on the Gasconade River (Parmalee 1965). The Tick Creek Cave assemblage was divided into Archaic and Woodland period subassemblages, each containing over 10,000 identified elements. Not surprisingly, a large number of species was identified. The assemblage was dominated by mammals, with numerous large species such as white-tailed deer, elk and even bison present. Medium to small species were also plentiful. Species such as the plains pocket gopher and bison, more common in western grassland environments, were identified in both the Archaic and Woodland assemblages. Much like the Sadie's Cave assemblage, aquatic bird species, while present, were represented by few individuals, except for trumpeter swans. Common bird species are raptors, pigeon, passerines, and terrestrial forms. Finally, fish are very uncommon

in this assemblage, although that may be due to recovery techniques. Parmalee (1965: 3) indicates that there was little change in faunal exploitation between the Archaic and Woodland inhabitants of Tick Creek Cave. Exploitation centered on species found within the surrounding forest and secondarily on those species more common to upland prairies.

In many respects, the assemblage and interpretations discussed by Parmalee (1965) for the larger Tick Creek Cave assemblage are mirrored in the smaller Sadie's Cave assemblage. While differences are present between the subassemblages at Sadie's Cave, they represent either slight changes in emphasis or are a reflection of sample biases. Perhaps if a finer-scale chronological framework had been available for the Tick Creek Cave analysis, Parmalee would also have identified slight changes in faunal exploitation. These variations, if valid, may have been due to a number of factors, including changing environmental conditions. Also similar to Tick Creek Cave, species adapted to forest habitats were most commonly represented, with fewer grassland species present. Taken together, the two assemblages indicate an emphasis on larger species and those species adapted to a number of environments. Such a strategy would minimize changes in assemblage composition during periods of environmental change. This would be consistent with the Sadie's Cave data, which indicate change restricted to increased use of previously exploited species, not the incorporation of new species into the faunal exploitation strategy practiced by the inhabitants.

Analysis of Archaeobotanical Remains

Botanical remains recovered from archaeological contexts offer the researcher a unique class of materials by which the dimensions of man-plant relationships may be explored, both in terms of environmental context and change through time. While the recovery of cultural artifacts may give an indication of the broad scope of economic activities undertaken by an archaeologically known cultural entity, preserved plant tissues allow for a much finer-grained view of the nature of economic pursuits and the cultural choices on which they are dependent. Archaeobotanical materials, when analyzed, may provide several types of information of interest to the archaeologist: phylogenetic relationships, usually when domesticated or cultivated plants are involved; data on cultural choice and/or habitat preference; seasonality of plant exploitation and site occupation; and, finally, paleoenvironmental reconstructions that are based in part on the types and quantities of preserved plant remains. Some authors, such as Ford (1982:282–295), draw distinctions between archaeobotany, the identification of plant remains from archaeological sites and paleoethnobotany, which may be regarded as the analysis of plant remains with the goal of describing and interpreting the cultural adaptation to the floral environment and those direct relationships between man and plant. These latter goals are adopted here and thus form the framework within which the Sadie's Cave botanical assemblage is analyzed and considered. There exists, however, no overriding methodology within which paleobotanical remains are sampled and analyzed, largely due to the vagaries of preservation and variation among assemblages.

The preserved botanical assemblage recovered from Sadie's Cave offers a means of assessing human-plant interactions in a single locality over nearly 9,000 years of prehistoric occupation. During this period the cultural adaptation of the site's inhabitants and the environmental conditions within which the occupations occurred did not remain static but instead were themselves dynamic forces that helped to shape the content of the paleobotanical materials represented in this sample.

Methods

Seventy-five flotation samples comprising a total of 632 liters of soil and feature fill collected during the Sadie's Cave Legacy Project excavations were processed with the aid of a Dausman Flote-Tech flotation system, using standardized procedures for both the collection and processing of the samples. The methodology employed in the collection, processing and analysis is designed to produce replicable, and therefore comparable, results within and between similar archaeobotanical assemblages. In general the sampling and processing procedures used follow those set forth by Asch et al. (1972), Pearsall (1989) and Wagner (1988).

Field and laboratory collection procedures have been described previously. Sample volumes were recorded in the laboratory prior to flotation processing. Volumetric control of the processed samples is critical in establishing a degree of comparability for discreet categories of remains between divergent sample sizes, both within and between assemblages.

In addition to the botanical remains recovered through flotation sampling, additional carbonized materials were hand collected during the excavations to serve as potential radiocarbon samples. All carbon samples chosen for radiometric assay were subject to identification prior to their submission. The hand-collected radiocarbon samples are not further considered in this report. A small number of hand-collected samples were also made of seeds observed in the field. While permitting no volumetric analyses, the charcoal obtained in this fashion serves as an important backup to the generally small flotation samples, and can often produce taxa not recovered within the systematically collected flotation samples.

Following the drying of the flotation remainders, the light and heavy fraction samples were sieved and prepared for analysis. The sieving of the flotation remainders was employed as an aid in sorting the various material classes present within the samples. All remainders were passed through both 2 mm and 1 mm geologic sieves. This process resulted in three size categories for each sample; $\geq$2 mm, $\geq$1–<2 mm, and <1 mm. The sorting procedure separated the carbonized remains in the $\geq$2 mm fraction from the mass of uncarbonized rootlets, small twigs and other inorganic debris (including other cultural material classes) that comprised the bulk of each sample. Uncarbonized seeds were sorted for potential identification. The <1 mm material was then visually scanned with the aid of a stereoscopic dissecting microscope for any identifiable seeds. Any such materials identified were then separated from the remainder of this fraction, which was not further analyzed. An aggregate weight of carbonized material was recorded for the $\geq$2 mm size fraction and the presence/absence of wood, nutshell and other types of materials were noted. The 1–2 mm fraction was similarly divided into subcategories such as nutshell, wood, seeds, and other types of material. All categories were counted, weighed and recorded.

Following the sorting and initial divisions into the various categories of botanical remains, the task then shifted to identification. Identifications were aided by the use of a dissecting scope capable of 10.5x to 63x magnification and were made by referring to both standard reference manuals (Core et al. 1979; Martin and Barkley 1961; Montgomery 1977; United States Department of Agriculture, Forest Service [USDA] 1974) and to a large comparative collection of carbonized and fresh botanical materials maintained by the Department of Anthropology, University of Illinois at Urbana-Champaign. Identifications of all nonwood materials $\geq$2 mm were attempted with the goal of at least the genera level of taxonomic specificity. Seeds and materials other than wood and

nutshell extracted from the 1-2 mm fraction were also subject to this identification procedure. Within each sample, wood charcoal identification was made either for all pieces present within the ≥2 mm assemblage, or for 20 randomly selected pieces for larger assemblages.

Analysis and consideration of the implications of the archaeobotanical assemblage were made within the framework of the analytical unit, defined on the basis of combined stratigraphic/sedimentary context, radiocarbon assay and the presence of temporally diagnostic artifacts. This approach results in the combination of numerous discrete samples representing arbitrary excavation levels into more manageable and archaeologically meaningful aggregates. Throughout the discussion of these remains, a distinction will be maintained between those recovered from discrete feature contexts and the remainder of the assemblage, which was derived from arbitrary excavation levels within stratigraphic units.

Results

Flotation processing of the 632 liters of general sediment matrix and cultural feature fill collected from Sadie's Cave, and the subsequent sorting and analysis of the flotation residues resulted in the amassing of 370.8 grams of carbonized archaeobotanical material ≥1 mm diameter. These remains consist primarily of wood, bark and nutshell, with lesser quantities of seeds and other plant tissues included. The identification and analysis of these remains offers a means of assessing both the composition of the immediate floral environment of the site and the behavior of human occupants of the cave with respect to various components of the floral community. The identified archaeobotanical remains recovered through flotation sampling of the Sadie's Cave excavations are presented in Tables 31-35.

Test Unit 2/6. A total of 27 samples comprising 213 liters of sediment was collected from TU2/6 contests (Table 31). Of these samples, five were collected from features (Features 2, 104 and 112), and the remainder from general excavation levels. In aggregate, 37.3 g of charcoal were recorded with 5.5 g originating from feature contexts and the remainder derived from excavation levels.

Stratum 1 produced the greatest quantity of carbonized remains (19.5 g), including 10.7 g of wood and 1.6 g of nutshell ≥2 mm in size. Wood charcoal identified as oak (genus *Quercus*) dominates the identified sample, with lesser amounts of hickory (*Carya* sp.), hard maple (*Acer* sp.) and eastern red cedar (*Juniperus virginiana*) present. Nutshell recovered from Stratum 1 are overwhelmingly those of the hickory nut (128 fragments) with minute amounts of black walnut (*Juglans nigra*; 3 fragments) and acorn (1 fragment) recorded.

Six carbonized seeds were recovered, five identified as basswood (*Tilia americana*) and one identified as wild grape (*Vitis* sp.). Also recovered from Stratum 1, and throughout most of the samples, were the uncarbonized calcareous endocarps or stones of the hackberry (*Celtis occidentalis*). These stones are extremely hard and tough and therefore resistant to rapid degradation following their dispersal. A single seed of *Lithospermum* sp., representing one of several species of gromwell, a prairie-adapted wildflower, was recovered from TU2/L4. This genus also produces a calcareous seed which gives rise to the descriptive genus name "stone seed." Given the difficulty in attributing the presence of the uncarbonized hackberry and gromwell remains in Sadie's Cave to either cultural or natural mechanisms, these seeds and seed fragments are not included within the calculations of

Table 31. Archaeobotanical Remains from Flotation Samples from Sadie's Cave Test Unit 2/6.

	Stratum 1	TU2 L-4	Stratum 2	Stratum 3	Stratum 5	Stratum 7	Stratum 6	Feature 112 Stratum 1	Feature 104 Stratum 1/2	Feature 2 Stratum 3
Number of Samples	3	1	6	6	4	1	1	1	1	3
Volume (liters)	22	7	41	52	37	7	10	3	6	28
Identified wood	42	17	88	59	22	-	-	0	20	54
Wood Taxon										
Acer sp.	2	-	-	-	-	-	-	-	-	-
Carya sp.	6	-	-	-	-	-	-	-	-	-
Juniperus virginiana	1	-	-	-	-	-	-	-	-	-
Pinaceae	-	-	-	1	-	-	-	-	-	-
Quercus sp.	31	2	11	1	2	-	-	-	-	14
Tilia americana	-	-	-	1	-	-	-	-	-	-
Ring porous	-	15	70	56	20	-	-	-	14	40
Diffuse porous	-	-	7	-	-	-	-	-	6	-
Total wood ct/wt	1061/10.7g	26/0.1g	101/0.5g	59/0.4g	29/0.1g	-	-	-	23/0.1g	213/1.1g
Nutshell										
Carya sp.	128	11	208	220	12	-	-	-	3	521
Juglans nigra	3	-	-	4	-	-	-	-	-	-
Quercus sp.	1	-	-	-	-	-	-	-	-	-
Unidentified	-	-	1	-	-	-	-	-	-	-
Total nutshell ct/wt	132/1.6g	11/0.2g	209/1.7g	224/2.1g	12/0.2g	-	-	-	3/0.1g	521/3.5g
Seeds										
Tilia americana	5	-	-	-	-	-	-	-	-	-
Vitis sp.	1	-	-	-	-	-	-	-	-	-
Unidentified	2	-	3	4	-	-	-	-	-	-
*Celtis occidentalis**	2	2	45	58	24	-	-	2	-	34
Lithospermum sp.*	-	1	-	-	-	-	-	-	-	-
Total weight[1]	19.5g	0.9g	4.4g	4.7g	2.2g	n/a	0.1g	0.4g	0.4g	4.7g
Charc. density g/10l	8.86	1.29	1.07	0.90	0.59	n/a	0.1	1.3	0.67	1.68
Nutshell/wood ratio	0.12	0.42	2.07	3.8	0.41	n/a	n/a	n/a	0.13	2.45
Seed/nutshell ratio	0.06	n/a	0.01	0.02	n/a	n/a	n/a	n/a	n/a	n/a

* Denotes uncarbonized seeds/fragments which are not included in density or ratio statistics.

[1] Total weight includes all charcoal from $\geq$1 mm and $\geq$2 mm sieve fractions.

Table 32. Archaeobotanical Remains from Sadie's Cave Test Unit 3 Flotation Samples.

	Stratum 1	Level 3 Stratum 1/2	Stratum 2	Stratum 3	Level 7 Strata 3/4/5	Feature 4 Stratum 1	Feature 5 Stratum 2
Number of Samples	2	1	2	1	1	2	1
Volume (liters)	18	8	15	7	7	12	7
Identified wood	41	20	-	-	-	40	20
Wood Taxon							
Catalpa	2	-	-	-	-	-	-
Carya sp.	-	-	-	-	-	1	-
Fraxinus nigra	2	-	-	-	-	4	-
Juniperus	-	-	-	-	-	1	-
Pinaceae	1	-	-	-	-	2	3
Quercus sp.	12	13	-	-	-	17	-
Tilia americana	-	-	-	-	-	1	-
Ulmaceae	-	-	-	-	-	1	-
Ring porous	24	6	-	-	-	12	12
Diffuse porous	-	1	-	-	-	-	5
Total wood ct/wt	615/4.9g	32/0.1g	-	-	-	1406/11.	125/0.6g
Nutshell							
Carya sp.	187	87	164	-	-	137	92
Quercus sp.	1	-	-	-	-	5	-
Total nutshell ct/wt	188/2.5g	87/0.9g	164/1.9g	-	-	142/2.4g	92/0.9g
Seeds							
Chenopodium album	1	-	-	-	-	-	-
Unidentified	1	-	-	-	-	1	-
*Celtis occidentalis**	14	10	-	-	-	5	11
Total weight[1]	7.4g	1.0g	3.5g	0.3g	-	13.5g	1.5g
Charc. density g/10l	4.11	1.25	4.38	0.43	n/a	11.25	2.14
Nutshell/wood ratio	0.31	2.72	n/a	n/a	n/a	0.10	0.74
Seed/nutshell ratio	0.01	n/a	n/a	n/a	n/a	0.01	n/a

* Denotes uncarbonized seeds/fragments that are not included in density or ratio statistics.
[1] Includes all charcoal from the $\geq$1 mm and $\geq$2 mm sieve fractions.

Table 33. Archaeobotanical Remains from Sadie's Cave Test Unit 4/5 General Excavation Level Flotation Samples.

	Stratum 1	Stratum 2	TU4/L-4 and TU5/L6 Strata 2/3-5	Stratum 3-5	TU5 L-11	Stratum 7	Stratum 8
Number of Samples	2	6	2	8	1	3	4
Volume (liters)	20	59	19	75	10	32	30
Identified wood	40	97	40	78	20	-	20
Wood Taxon							
Acer sp.	5	-	-	-	-	-	-
Carya sp.	-	-	4	-	-	-	-
Fraxinus nigra	-	2	-	-	-	-	-
Juniperus virginiana	-	-	-	2	-	-	-
Platanus	-	4	-	-	-	-	2
Quercus sp.	17	60	16	10	9	-	2
Tilia americana	-	1	-	-	-	-	-
Ring porous	18	29	20	54	3	-	6
Diffuse porous	-	1	-	2	8	-	10
Total wood ct/wt	112/0.9g	1174/7.7g	73/0.6g	150/1.0g	26/0.1g	-	29/0.1g
Nutshell							
Carya sp.	1	249	40	86	-	-	10
Juglans nigra	-	3	-	-	-	-	-
Quercus sp.	1	2	-	-	-	-	-
Corylus americana	-	3	-	-	-	-	-
Total nutshell ct/wt	2/0.1g	257/4.1g	40/0.8g	86/1.0g	-	-	10/0.1g
Seeds							
Chenopodium sp.	29*	2	-	-	-	-	-
Graminae	-	-	1	-	-	-	-
Scirpus sp.	-	-	-	1	-	-	-
Vitis sp.	-	-	-	-	-	-	-
Unidentified	-	1	1	-	-	-	-
*Celtis occidentalis**	6*	45*	10*	309*	49*	34*	34*
Other							
Cucurbita sp. rind	-	7/0.1g	-	-	-	-	-
Bark	-	-	689/8.6g	82/1.3g	-	-	-
Total weight[1]	1.0g	24.4g	14.1g	6.6g	0.4g	1.4g	0.6g
Charc. density g/10l	0.05	4.13	7.05	1.00	0.4	0.44	0.2
Nutshell/wood ratio	0.02	0.22	0.55	0.57	n/a	n/a	0.34
Seed/nutshell ratio	n/a	0.01	0.05	0.01	n/a	n/a	n/a

* Denotes uncarbonized seeds/frags. that are not included in density or ratio statistics.

[1] Includes all charcoal from the $\geq$1 mm and $\geq$2 mm sieve fractions.

Table 34. Archaeobotanical Remains from Sadie's Cave Test Unit 4/5 Feature Flotation Samples.

	Feature 6 Stratum 2	Feature 101 Stratum 2	Feature 8 Stratum 2	Feature 9 Strata 3-5	Feature 119 Stratum 8
Number of Samples	1	1	2	1	1
Volume (liters)	10	10	7	13	6
Identified wood	20	20	20	-	-
Wood Taxon					
Quercus sp.	20	20	-	-	-
Ring porous	-	-	20	-	-
Total wood ct/wt	113/0.6g	30/0.1g	31/0.2g	-	-
Nutshell					
Carya sp.	11	-	11	-	-
Quercus sp.	-	-	3	-	-
Total nutshell ct/wt	11/0.1g	-	14/0.1g	-	-
Seeds					
Unidentified	1	-	-	-	-
*Celtis americana**	5*	5*	18*	20*	1*
Other					
Bark	-	-	4992/190.6g	-	-
Total weight[1]	0.7g	0.5g	253.8g	1.7g	0.1g
Charc. density g/10l	0.7	0.5	362.57	1.31	0.17
Nutshell/wood ratio	0.1	n/a	0.45	n/a	n/a
Seed/nutshell ratio	0.09	n/a	n/a	n/a	n/a

* Denotes uncarbonized seeds and fragments not included in density or ratio statistics.
[1] Includes all charcoal from ≥1 mm and ≥2 mm sieve fractions.

total charcoal weight or in the seed/nutshell ratios for each discrete depositional provenience. The remaining strata all produced similar spectra of wood and nutshell charcoal, although in significantly lesser quantity than Stratum 1.

Table 35. Archaeobotanical Remains from Sadie's Cave Test Unit 7 Flotation Samples.

	Stratum 1	Level 2	Stratum 3	Stratum 4	Stratum 5
Number of Samples	1	1	1	1	1
Volume (liters)	9	7	8	9	9
Identified wood	20	20	-	-	-
Wood Taxon					
Juglans nigra	3	-	-	-	-
Quercus sp.	10	-	-	-	-
Ring porous	6	20	-	-	-
Diffuse porous	1	-	-	-	-
Total wood ct/wt	154/1.1g	50/0.4g	-	-	-
Nutshell					
Carya sp.	63	110	68	-	-
Total nutshell ct/wt	63/1.4g	110/0.8g	68/0.7g	-	-
Seeds					
*Celtis americana**	3*	-	18*	-	-
Total weight	2.5g	1.2g	0.7g	0.1g	-
Charc. density g/10l	3.09	1.71	0.88	0.11	n/a
Nutshell/wood ratio	0.41	2.2	n/a	n/a	n/a
Seed/nutshell ratio	n/a	n/a	n/a	n/a	n/a

* Denotes uncarbonized seeds and fragments not included in density or ratio statistics.

Three features were excavated within TU2/6. Feature 112 was located within Stratum 1, Feature 104 at the Stratum 1/2 boundary, and Feature 2 was defined in Stratum 3 near the Stratum 3/5 boundary. Feature 112, dating to the Woodland period, produced only 0.4 g of charcoal, none of which was $\geq$2 mm in size. Feature 104, possibly Late Archaic in age, also produced little charcoal, 0.4 g, and only 23 fragments of wood charcoal $\geq$2 mm. Twenty randomly selected fragments of the wood charcoal were identified as representing ring-porous (14 fragments) and diffuse-porous taxa (6 fragments). The extremely small size of the charcoal recovered from Feature 104 precluded more precise identifications at low-power magnification. Feature 2, a human burial located at bottom of Stratum 3, produced a moderate assemblage of carbonized plant materials, including 1.1 g of wood and 3.5 g of charred nutshell. This feature has been radiocarbon dated to 7780$\pm$70 B.P., placing it in the early portion of the Middle Archaic Period (Ahler et al. 1995:132 and above discussion). The wood charcoal included both *Quercus* (14 fragments), and ring-porous taxa (40 fragments) in the $\geq$2 mm fraction. Hickory nutshell fragments accounted for all of the 521

fragments recovered. Uncarbonized *Celtis occidentalis* seeds or fragments (n=34) also were recovered from Feature 2.

Test Unit 3. Nine flotation samples were collected from TU3, including six from general excavation levels totaling 48 liters, and three from Features 4 and 5) totaling 19 liters (see Table 32). Of the samples collected from general excavation levels, only strata 1 and 2 produced carbonized remains $\geq$2 mm in size. Stratum 1 also contained two carbonized seeds, one of which was identified as a wild morph of chenopod, likely *Chenopodium album*. The second seed was too badly charred and deformed for identification. The wood charcoal assemblages from both strata 1 and 2 are predominantly composed of *Quercus* sp. and ring-porous pieces, with *Catalpa bignonioides*, *Fraxinus nigra*, Pinaceae, and diffuse-porous fragments present in low numbers. Hickory nutshell again dominates the nutshell assemblage in strata 1 and 2 with only a single fragment of acorn shell present in Stratum 1. Again, the uncarbonized endocarps of *Celtis occidentalis* are well-represented. A single sample recovered from Stratum 3 produced 0.3 g of charcoal, and a sample from Level 7 (mixed strata 3/4/5 contexts) produced no carbonized remains.

Two cultural features were excavated in TU3. Feature 4 is associated with Stratum 1 and Feature 5 is located near the top of Stratum 2. Both of these discrete depositional contexts produced substantially more charred botanical material (in terms of grams/10 liter standardized density values) than the general excavation level samples. However, only Feature 4 produced a larger total weight of carbonized material than that of the most productive Stratum 1 samples (see Table 32). The diversity of the wood taxa represented in Feature 4 also exceeds all other sampled proveniences in TU3, with eight taxa identified: *Fraxinus nigra, Juniperus virginiana, Quercus* sp., *Tilia americana,* Ulmaceae, Pinaceae, and ring-porous hardwood. Again, *Quercus* sp. and ring-porous hardwood dominate the identified sample. *Carya* sp. nutshell accounts for over 96 percent of the fragments recovered from Feature 4 and all of the nutshell from Feature 5, amounts that are not at all divergent from the nutshell assemblage recovered from general excavation level samples from TU3. A single unidentified charred seed was recovered from Feature 4, and both features contained uncarbonized examples of *Celtis occidentalis*.

Test Unit 4/5. Test Unit 4/5 represents the most intensively sampled excavation unit pair, with 26 samples collected from general excavation levels totaling 245 liters of sediments, and six samples collected from five cultural features totaling 45 liters of fill. These remains are summarized in Tables 33 and 34, respectively. In general the remains recovered from the general stratigraphic samples mirror the Test Units previously discussed in terms of the various taxa represented, although several of the strata within TU4/5 produced significantly larger charcoal assemblages. Stratum 2 in particular is notable in that 24.4 g of charcoal was recovered from 59 liters of processed sediments, resulting in a charcoal density of 4.13 g/10 liters. Over 1,100 fragments of wood charcoal were recovered from the $\geq$2 mm fraction, as were 257 fragments of nutshell weighing 4.1 g. The nutshell assemblage is notable for the presence of three fragments of american hazelnut (*Corylus americana*), and three fragments of black walnut (*Juglans nigra*). Taken together, however, the *Corylus* and *Juglans* fragments make up only 1.9 percent of the Stratum 2 nutshell assemblage which includes 96.8 percent *Carya* and less than one percent *Quercus* fragments.

In addition to the wood and nutshell, Stratum 2 also produced three carbonized seeds, two *Chenopodium* sp. and one unidentified. The chenopod seeds morphologically appear to be wild

morphs, likely *Chenopodium album*, and their presence may reflect incidental carbonization and inclusion rather than intentional collection and processing. Most interesting are seven small *Cucurbita* sp. (squash/gourd) rind fragments, which in aggregate weigh only 0.1 g.

A single 10-liter sample from TU5/L-6 contained 689 fragments of carbonized bark with a total weight of 8.6 g, which accounts for over 61 percent of the total carbonized remains recovered from this provenience. This bark likely originated in Feature 8, a shallow bark-filled basin, which has been subsequently partially disturbed by rodent burrows.

Five cultural features were located within TU4/5. Three of these, Features 6, 101 and 8, were located within Stratum 2 and date to the Woodland period. Of these, only Feature 8 produced a significant quantity of carbonized botanical material (Table 34). This feature contained nearly 5,000 fragments identified as charred tree bark with a total weight of 190.6 g, which accounts for 75 percent of the archaeobotanical remains recovered from this feature. Features 9 and 119, which are assigned to the Late Archaic and early Middle Archaic periods respectively, produced little in the way of substantive botanical materials. As with most of the sampled proveniences, all of the cultural features from TU4/5 contained uncarbonized *Celtis occidentalis* endocarps.

Test Unit 7. Five samples totaling 42 liters of sediments were collected and processed from TU7 (Table 35). With the exception of samples from Stratum 1 and Level 2, none of the samples produced more than 0.7 g of charcoal; Stratum 5 produced no carbonized archaeobotanical remains. The small quantities of wood and nutshell charcoal recovered from this analytical unit are in no way divergent from those recovered in the remainder of the analyzed archaeobotanical samples.

Discussion

The program of extensive flotation sampling of both general excavation unit levels and cultural features undertaken at Sadie's Cave has produced a relatively small and homogenous archaeobotanical assemblage. Despite the overall paucity of archaeobotanical remains, however, the assemblage does permit inquiry into the nature of human occupancy of the cave and the behavior of the occupants toward the floral environment. In this manner such issues as the immediate floral community composition, seasonality of occupation, dietary importance of particular plant taxa, and the exploitation of preferential habitats can be addressed. In a less direct manner, the assemblage also offers insights into potential alterations of the floral environment through time, particularly during the middle Holocene Hypsithermal Interval, and the nature of human response to such alterations. Each of the categories of charred archaeobotanical remains present within Sadie's Cave—wood charcoal, nutshell, seeds, and other plant tissues—offers evidence on the nature of man-plant interactions in this portion of the Ozark Highlands.

Perhaps the most serious limitation of the Sadie's Cave assemblage, aside from its size, is attributable to transformation processes (Schiffer 1976) operating on the botanical materials between their utilization/deposition and subsequent archaeological recovery. Here the dominant destructive process is the great degree of mechanical degradation and fragmentation which resulted largely from unprotected depositional environments within the cave. Along with more durable indicators of human presence within the excavated strata, charred plant remains were thinly distributed throughout much of the Holocene sequence. Deposition on the cave floor, however, as might be expected from surface fires built for warmth or limited cooking activities, has led to the subsequent breakage, size

reduction and no doubt total destruction of many of the ecofacts once present within the site through trampling and other activity-related means, as well as through exposure to adverse soil fauna, fungi, and other environmental agents of breakdown (Dimbleby 1967:93–103). Even under these adverse conditions of preservation, some general temporal trends can be examined for various classes of archaeobotanical remains.

Wood Charcoal. The wood charcoal preserved at Sadie's Cave reveals the presence of relatively few of the taxa that would be expected to have occurred prehistorically within the Oak-Hickory Forest Region, which is at its most diverse within this interior plateau landscape (Braun 1950). Within this climax forest association, significant differences in terms of constituent taxa are apparent between the xeric, rocky uplands where oaks predominate with or without associated hickories, and the more mesic ridgeslopes and valley floor settings that support a variety of other hardwoods such as maple, hornbeam and black walnut in association with dogwood, paw paw and other understory trees. In addition, mature stands of oak-pine climax forest and patchy areas of "barrens" or hill prairies could be expected on ridge crests. Eastern red cedar often are pioneering trees in the open, herbaceous-dominated openings (Braun 1950: 162–170; Steyermark 1963).

The Sadie's Cave charcoal assemblage reflects the primary exploitation of *Quercus* sp. and other ring-porous hardwoods as fuel sources, with more mesic-adapted taxa such as *Acer* sp., *Tilia americana*, and Ulmaceae (elm family) relatively minor components of the fuel assemblage. The sporadic occurrence of *Juniperus virginiana* indicates the presence of open prairie patches relatively nearby. It should be remembered that the wood charcoal present within the cultural deposits passed through a "cultural filter" and is therefore altered in often unreconstructable manner. Asch and Asch (1985) have proposed the Firewood Indifference Hypothesis to potentially account for this cultural selectivity, with an eye toward minimization of effort. The basic thrust of this hypothesis is that:

> ...economy of effort dictated the use of the nearest available dead wood for the every day cooking and heating fires that would have produced the bulk of the wood charcoal preserved at the site [Asch and Asch 1985:346].

With the adoption of such a perspective, the Sadie's Cave assemblage points to the primary collection of wood from the ridge crest and upper slopes near the cave, supplemented by wood from the lower slopes and bluff base, where higher proportions of mesic taxa would be expected.

In addition to the carbonized wood recovered within the cave, several contexts produced large quantities of charred bark. Feature 8, at the bottom of TU5/S2B, produced a total charcoal weight of 253.8 g, of which 190.6 g were charred tree bark. The Level 6 and the uppermost TU5/S3-5 sample both contained bark—8.6 g and 1.3 g, respectively. The presence of substantial quantities of bark may indicate the use of bark as fuel or pit lining, or indicate the partial combustion of bark-encased wood, with the outer bark layers not being totally combusted. The paucity of carbonized wood in association with these quantities of bark lends support to the interpretation that the bark was either used as fuel or some type of lining or covering.

Nutshell. In a similar vein the nutshell present at the site points to the near total dominance of upland-derived hickory, comprising 98.8 percent of the total assemblage by count, with minute contributions of black walnut (0.44 percent), acorns (0.57 percent) and hazelnuts (0.13 percent). The hickory, walnut and hazelnuts are all good sources of both protein and fat, while acorns are

carbohydrate rich and relatively poor in fat and protein content (Asch et al. 1972:25). Acorns also require additional processing, usually leaching in a mild lye solution, to reduce the high tannic acid content prior to human consumption (Yarnell 1964:69–70). Throughout the long Archaic period and into the Woodland period, nut resources have provided a major component to prehistoric diets throughout the eastern woodlands. Hickory nuts have been described as a "first-line" wild plant resource at the stratified Koster site, located in the lower Illinois River valley, where they dominate the nutshell assemblage nearly as thoroughly as at Sadie's Cave. At Koster, hickory nuts are seen as such a complete source of fats and protein that this resource becomes a focal point of the localized subsistence base (Asch et al. 1972:27–28). It would appear that hickory nuts serve a similar role in the subsistence of the occupants of Sadie's Cave, although the nature of the site, likely a temporary or special-purpose encampment, is in no way similar to that of a base camp as is postulated for Koster.

In addition to serving as indicators of prehistoric dietary components, the presence of charred nutshell also provides clues to the seasonal of occupation. Hickory nuts, acorns, and black walnuts all mature and are available during the autumn months, while hazelnuts generally mature in the late summer and early autumn (Asch et al. 1972:9; USDA 1974:343–345). Given the presence of carbonized examples of all of these taxa within the deposits at Sadie's Cave, human occupation of the site can be said to have occurred at least during the autumn. The storability of nuts, however, makes it possible that the presence of these remains reflects the use of stored resources in the cave at virtually any time of the year.

Seeds. With the exception of the numerous and nearly ubiquitous uncarbonized seeds of the hackberry, *Celtis occidentalis*, seeds are poorly represented in the Sadie's Cave archaeobotanical assemblage. Seventeen charred seeds were recovered from the samples. Five seeds were unidentified due to significant degrees of charring, deformation and the loss of diagnostic external characteristics. Each of the identifiable taxa will be briefly described in terms of habitat, seasonality of availability, and potential human usage based on ethnographic and archaeological data.

Five charred seeds identified as *Tilia americana*, or basswood, were recovered from TU2/S1. Basswood underbark fiber is recognized as an important source of material used in basketry, netting and other applications that require strong cordage (Yarnell 1964:190). No significant usage of the seeds is noted, and the presence of the seeds within the cave likely represents accidental inclusion, since basswood appears in the wood charcoal assemblage of TU2.

Three charred chenopod (*Chenopodium* sp.) seeds were recovered from general excavation level samples in TU3 and TU4/5. Chenopodium is a well-documented member of the eastern agricultural complex, a suite of starchy and oily-seeded plants that were included in aboriginal horticultural systems as early as the Late Archaic period and that show signs of partial domestication (Heiser 1985; Smith 1992; Watson 1985). The three chenopod seeds from Sadie's Cave are small and badly charred, but fall well within the size range of wild *Chenopodium album*. Given both the small size and sparse representation within the cave, these seeds are best interpreted as accidental inclusions within the cave deposits, perhaps as result of the use of dried chenopod plants as tinder.

A single, charred wild grape seed was recovered from TU2/Stratum 1. Wild grapes are early autumn-ripening fruits that are generally found along stream banks, in thickets and in areas of rich soil. Such habitats could have been easily found within a short distance of the cave along the lower

bluff slopes and Big Piney River bottomlands. Fruits that remain on the vine following frosts are sweeter than those harvested earlier as the cold temperatures partially break down the sugars. Aboriginal uses include both consumption of fresh and dried fruits for food and also use for medicinal purposes (Yarnell 1964:65).

A single seed identified as belonging to the genus *Scirpus*, which includes the bulrushes and other aquatic rushes, was recovered from TU5/Stratum 3–5. The various rushes served as material for basketry and matting construction (Yarnell 1964:186–187). No aboriginal use of the seeds is indicated. Rushes could have been found along the riverbanks below the site.

A single unidentified charred grass seed was recovered from TU5/L4. Many grasses are native to Missouri and occupy habitats ranging from the open prairies of the western portion of the state, the smaller hill prairies and open glades common in the Ozark Plateau, to the more shaded and mesic communities within primarily forested areas (Kucera 1961:225–228). The single grass specimen from Sadie's Cave may have originated in a nearby hill-prairie context and have been incorporated as result of the use of dried grass as tinder. Grasses set seed throughout the summer and autumn months, depending on species.

The small carbonized seed assemblage from Sadie's Cave does not easily allow for definitive statements to be made regarding the importance of seeds in a dietary sense. It would appear that the low numbers, diverse taxa represented and lack of clearly domesticated forms are indicative of primarily accidental inclusion or the use of dried plants with attached seeds as tinder as a means of their introduction into the cave deposits. No evidence of seed caching or storage is indicated.

In addition to the carbonized seeds, uncarbonized seeds identified as *Celtis occidentalis, Chenopodium* sp. and *Lithospermum* sp. also were recovered. The *Celtis occidentalis* seeds and seed fragments are widespread throughout the deposits and as mentioned earlier likely represent the introduction of hackberries into the cave through natural means. The dense calcareous seed is very resistant to decay, a condition which accounts for the presence of this seed type in unprotected and early depositional units. Similarly, the seed of *Lithospermum* sp. recovered from TU2/L4 also has a calcareous endocarp. The genus *Lithospermum* includes several species of gromwell, prairie-adapted wildflowers that would have been at home in localized ridgetop prairies in the vicinity of the site. Both of these seed types could have been introduced into the cave by either transport with eroding sediments from the upper ridge slope which have formed a cone in front of the cave mouth, or via any of a number of faunal transport mechanisms.

Chenopodium is commonly found in areas of disturbed ground as a colonizing or adventive plant. The Big Piney River bottomlands, river sand and gravel bars, and the lower slopes of the bluffs would offer potential habitat for chenopod. All of the uncarbonized chenopod (29 seeds) was recovered from TU5/Stratum 1, where this taxa could potentially represent a modern contaminant.

Other Remains. Stratum 2 of TU5 produced seven minute fragments of charred squash rind in the 1–2 mm sieve fraction. Archaeological specimens of *Cucurbita* rind are known from Late Archaic Sedalia Phase contexts at Phillips Spring in Missouri (Kay et al. 1980; Kay 1986), Archaic contexts at the Koster and Napoleon Hollow sites in the lower Illinois River valley (Asch and Asch 1982), several Archaic sites in the Little Tennessee River Valley (Chapman and Shea 1977), and from Salts Cave in Kentucky (Yarnell 1969). Archaeological *Cucurbita* seeds dating to the middle

Holocene are known from Phillips Spring and the Bacon Bend site in eastern Tennessee (Smith 1992). Cucurbits are thus an early and important member of aboriginal horticultural systems and retain this status throughout all of North American prehistory. Despite taxonomic and evolutionary arguments regarding the tropical or indigenous status for early examples of archaeological *Cucurbita* (Smith 1992), this plant has a long history of human utilization and husbandry in portions of eastern North America.

Difficulty arises in attempting to ascribe the few, minute rind fragments from Sadie's Cave to either of the several varieties of *Cucurbita pepo*, a known domesticated variety of squash, or to the indigenous *Cucurbita foetidissima*, the coyote melon or buffalo gourd (King 1985). It was believed that early specimens of *C. pepo* and all examples of *C. foetidissima* possess rinds generally less than 2 mm in thickness which are impossible to distinguish morphologically, while later domesticated varieties of *C. pepo* generally have rinds greater than 2 mm thick. Subsequent studies have show the squashes to have variable rind thickness. Such investigations also revealed that what is identified as the rind or exterior skin is actually composed of only the lignified hypodermis (Ford 1989). The specimens from Sadie's Cave are well below 2 mm in thickness but have suffered an unknown degree of abrasion and wall thickness reduction resulting from both carbonization and mechanical, postdepositional processes.

Given the stratigraphic placement of the Sadie's Cave cucurbit rind in mixed Middle and Late Woodland contexts, it is tempting to conclude that the rind represents domesticated *Cucurbita pepo* rather than wild *Cucurbita foetidissima*. Such a conclusion is unwarranted, however, given the small sample size, lack of more diagnostic seeds and the location of the site within the range of the wild taxa. Nevertheless, the presence of cucurbit rind at the site does suggest the use of some variety of this plant as a container by the Woodland Meramec Springs-affiliated occupants of the cave.

Temporal Trends. The above discussion of the plant taxa represented within Sadie's Cave has stressed the environmental, seasonal and preservational aspects of the assemblage with little attention to the chronological relationships between the described categories of archaeobotanical remains. Given the stratified nature of the site, chronological trends or patterning within the remains may offer additional information regarding the nature of the site's occupation and how this may have changed through time. Additionally, the effects of the middle Holocene Hypsithermal Interval on the local floral community, if any, may be visible in the distribution of archaeobotanical materials. In order that such topics may be addressed, Table 36 summarizes the archaeobotanical assemblage by strata set without reference to the horizontal location of the samples within the cave. The strata sets are correlated time-stratigraphic units constructed on the basis of general strata composition, radiocarbon assays, and the presence of diagnostic artifacts.

Strata Set A contains Middle and Late Woodland diagnostic cultural materials which may date to as early as 1700 B.P. Twenty-two samples totaling 176 liters of processed sediments are assigned to Strata Set A. This strata set contains by far the vast majority of the archaeobotanical remains recovered at the site, and is the most diverse in terms of the range of plant taxa represented in all categories of remains. The assemblage from this provenience is dominated by charred tree bark, recovered from Feature 8, accounting for 58.95 percent of the material by weight. Strata Set A also produced the majority of charred seeds and nutshell recovered from the site. The great disparity in terms of the quantities and range of materials present within Strata Set A and the rest of the strata may be in part attributable to a change in the role Sadie's Cave played in the overall settlement

Table 36. Archaeobotanical Remains from Flotation Samples Tabulated by Strata Set.

	Strata Set A	Strata Set B	Strata Set C	Strata Set D	Strata Set E	Strata Set F
Number of Samples	21	21	9	4	8	1
Volume (liters)	169	173	84	37	61	10
Identified wood	340	214	59	22	20	-
Wood Taxon						
Acer sp.	7	-	-	-	-	-
Carya sp.	7	-	-	-	-	-
Catalpa bignonioides	2	-	-	-	-	-
Fraxinus nigra	8	-	-	-	-	-
Juglans nigra	3	-	-	-	-	-
Juniperus virginiana	2	2	-	-	-	-
Platanus occidentalis	4	-	-	-	2	-
Pinaceae	3	3	1	-	-	-
Quercus sp.	167	34	1	2	2	-
Tilia americana	2	-	1	-	-	-
Ulmaceae	1	-	-	-	-	-
Ring porous	129	154	56	20	6	-
Diffuse porous	2	21	-	-	10	-
Total wood ct/wt	4687/37.3g	399/2.3g	59/0.4g	29/0.1g	29/0.1g	n/a
Nutshell						
Carya sp.	787	708	220	12	10	-
Corylus americana	3	-	-	-	-	-
Juglans nigra	6	-	4	-	-	-
Quercus sp.	13	-	-	-	-	-
Unidentified	-	1	-	-	-	-
Total nutshell ct/wt	809/12.3g	709/7.2g	224/2.1g	12/0.2g	10/0.1g	n/a
Seeds						
Chenopodium sp.	3/29*	-	-	-	-	-
Scirpus sp.	-	1	-	-	-	-
Tilia americana	5	-	-	-	-	-
Vitis sp.	1	-	-	-	-	-
Graminae	1	-	-	-	-	-
Unidentified	6	3	4	-	-	-
*Celtis occidentalis**	109	403	92	24	35	-
Other						
Cucurbita sp. rind	7/0.1g	-	-	-	-	-
Bark	4992/190.6g	82/1.3g	-	-	-	-
Total weight[1]	323.3g	20.1g	6.1g	2.2g	0.8g	0.1g
Charc. density g/10l	19.13	1.16	0.73	0.59	0.13	0.1
Nutshell/wood ratio	0.17	1.78	3.80	0.41	0.34	n/a
Seed/nutshell ratio	0.02	0.01	0.02	n/a	n/a	n/a

* Denotes uncarbonized seeds/fragments which are not included in density or ratio statistics.
[1] Total weight includes all charcoal from $\geq$1 mm and $\geq$2 mm sieve fractions.

system. The greater density of charred botanical materials may reflect more frequent, though no more intensive, use of the site as a specialized encampment. Similarly, the presence of *Cucurbita* rind fragments, albeit in minute amounts, suggests that storage of subsistence or other items may have occurred at this time, although the primacy of hickory nutshell indicates that this plant resource was perhaps most important.

Strata Set B, dating to the Late Archaic Period between 3000–5000 B.P. contains a similar though far less abundant assemblage as that found in the overlying stratum. The wood charcoal assemblage is again dominated by the oaks and the nutshell by hickory. Wood charcoal is far less common, only about six percent by weight of that found in Strata Set A, while the nutshell assemblage is 43 percent of that from Strata Set A by weight. The nutshell to wood ratio for this strata set (1.78) is, however, far higher than that for Strata Set A. This may be due in part to a higher survivability for nutshell in unprotected depositional contexts compared to wood charcoal. It is likely, though, that Late Archaic populations of the region were more heavily dependent on hickory nuts than were later populations that may have been more heavily involved in horticultural activities.

Strata sets C and D represent the Middle Archaic Period of occupation of Sadie's Cave, with Strata Set C dating between 5000–7000 B.P., and Strata Set D dating between 7000–8000 B.P. Together these two strata sets cover the middle Holocene Hypsithermal Interval, a period of increasing climatic warming and desiccation that is postulated to have had major effects on human settlement in much of the North American midcontinent (Ahler 1984; Brown and Vierra 1983). With increasing temperatures and lessening mean annual precipitation, plant taxa capable of inhabiting more xeric locales were favored on the uplands, while stream valleys provided refugia for more mesic-dependent species. In the immediate locality of Sadie's Cave the upland vegetation can be expected to have become a mosaic of open prairie, oak savannah and open oak forest, while the Big Piney River valley probably saw little change in the overall composition of forested habitats.

Given these potential alterations in the floral communities present near the site, it might be expected that major changes would be noted in the archaeobotanical assemblage. This is not the case, however, for reasons that go beyond the documented climatic shift. First of all, the sample sizes are small from these two strata sets—6.1 g and 2.2 g, respectively. Second, cultural choices have in part masked the potential for identifying particular alterations in the floral composition. Hickory nutshell is again nearly completely dominant, with only a minute representation of black walnut. Acorns, which would be expected to have been a larger part of the overall available nut mast given the tolerance of xeric habitats by oaks, are entirely absent from the assemblage. Such a pattern suggests that the cultural preference for and selection of hickory outweighed the potential decrease in hickory nut productivity, and that the added costs associated with processing acorns for consumption were not offset by the potential increase in their availability. Thus cultural preference and selectivity that favor a particular resource, in this case the hickory nut, has effectively masked the effects of documented climatic change from visibility in the archaeobotanical assemblage. It is interesting to note that Strata Set C has the highest nutshell to wood ratio of all sampled strata sets (3.80), while it drops to a mere 0.41 in Strata Set D. This latter figure is no doubt greatly influenced by small sample size.

The basal strata sets, E and F, dating to the early Holocene and Pleistocene, are difficult to categorize due to the near-total lack of charred plant remains $\geq$2 mm in size. Strata Set E,

consisting of eight samples with a total volume of 61 liters, produced only 0.8 g of carbonized material, including 29 wood charcoal fragments and 10 nutshell. The wood charcoal, however, includes two fragments of *Platanus occidentalis*, or sycamore, along with 10 fragments identified as diffuse-porous. While an admittedly small sample, these taxa may suggest more mesic conditions prevailed in the immediate site locality. Strata Set F, consisting of a single 10-liter sample, produced no remains $\geq$2 mm in size and only 0.1 g of total charcoal.

Summary

The archaeobotanical assemblage recovered from Sadie's Cave reveals that the site's occupants relied on a variety of locally available native plant resources for subsistence, fuel and perhaps technological purposes. The taxa present within the site would have been available within a radius of several hundred meters of the site, and are primarily derived from the oak-hickory forest that mantled the uplands and portions of the ridge slopes above the Big Piney River. With regard to subsistence plants, hickory nut made the greatest contribution to the diet. These nuts present a compact and readily collected source of fat and protein during their autumn season of availability and lend themselves to storage for later consumption. Small quantities of black walnut, hazelnut and acorns attest to the diversity of nut resources available and to the degree of selectivity of the cave's occupants by their general paucity. Seeds are poorly represented within the cave, especially those of the starchy- and weedy-seeded annual plants that are described as comprising the eastern agricultural or horticultural complex. It is likely that the underrepresentation of these remains is more a function of site type, most likely a limited-activity or short-term encampment, rather than an indicator of their absence from the subsistence base during the Archaic and Woodland periods represented by these deposits. Similarly, no tropical cultigens were recovered. The picture we are left with is one in which autumn hickory nut mast is a staple resource exploited throughout the long span of occupation of Sadie's Cave.

Ceramic Analysis

Attributes of ceramic artifacts were described in detail on ceramic analysis forms. The formal ceramic typology for the region consists presently of only two indigenous described types, Maramec Cordmarked and Maramec Plain, (see Marshall 1958, 1965; McMillan 1965 for formal descriptions of these types). Both these types have a long history of manufacture and use, and little morphological variability through time has been described. Consequently, the ceramic recording form developed for this project was designed to be highly descriptive. Attributes of temper type, temper density and size, surface treatment, cord twist, decoration, vessel portion, vessel form, rim shape and method of manufacture, lip shape and treatment, rim orifice diameter, and thickness were recorded for each sherd, following standard definitions for these attributes (see Rice 1987; Shepard 1965). Each sherd was also placed in a ceramic type category for comparative purposes. The primary author described and analyzed the ceramic artifacts.

In spite of the overall uniformity of the Maramec ware ceramics through time, recent stratigraphic excavations conducted by the University of Illinois in 1992–93 (Ahler et al. 1995) provided a few additional observations on ceramic variability within the Late Woodland time frame. Plain and cordmarked surfaces predominate in all ceramic assemblages, though cord-impressed or knotted and fabric-marked sherds also were observed. These latter surface treatments appear to be

associated with late Maramec Spring Phase assemblages, such as those recovered from 23PU172 (strata 1–2), 23PU249 (Stratum 1), and 23PU265 (Stratum 1). In addition, a single, red-slipped sherd was recovered from Late Woodland contexts dating between about 530 and 1240 B.P. at 23PU249. Red-slipping may be a temporal indicator of late Late Woodland components in this region, and its use at this time would be consistent with red-slipping as a common decorative style in Mississippian and Caddoan assemblages from eastern and southern neighboring regions (Brown 1984; Chapman 1980; Reeder 1988).

These observations reinforced previous researchers' division of the Late Woodland Maramec Spring Phase into early and late segments, based on differences in ceramic and lithic typology (see Reeder 1988; Moffat et al. 1989). Early Late Woodland ceramic types include the usual Maramec Cordmarked and Plain types. There is apparently little decorative or technological variability in the Maramec wares during this time period. The later segment of the Late Woodland Maramec Spring Phase includes the addition of small arrow points such as the Scallorn and Reed Side-notched types to the armament assemblage and a more variable ceramic assemblage. Some vessels exhibit either shell tempering or a mixture of shell and other tempering agents. Bowl forms are present in small numbers. Red-slipping also may be associated with later Late Woodland developments. The temporal association of techniques such as fabric-marking and cord impressing has not yet been established, though they are probably associated with the later half of the Late Woodland temporal span.

Ceramic types associated with the Early and Middle Woodland periods have not been observed either within Fort Leonard Wood assemblages or in general in the Ozark Highland region. One exception is recovery of a Hopewell-like dentate-stamped sherd of probable nonlocal manufacture from the surface at 23PU265. However, test excavations conducted at this site in 1993 (Ahler et al. 1995). revealed no other Middle Woodland-age ceramics of either local or nonlocal origin. Instead, an aceramic assemblage associated with straight-stemmed points similar to SS4 (McMillan 1965; Roberts 1965) or Verkamp Stemmed (Chapman 1980) points were recovered from contexts radiocarbon dated to the late Middle Woodland period (1700–1800 B.P.). These data are reinforced by evidence from the Feeler site in Maries County where a nonceramic horizon of Middle Woodland age was identified stratigraphically beneath ceramic Late Woodland horizons (Reeder 1988).

Based on these trends and the known range of radiocarbon assays, we expected that the ceramic assemblage from Sadie's Cave would be dominated by Late Woodland Maramec wares. Presence of two radiocarbon assays dating to 950 B.P. and three others in the 1400–1700 B.P. range indicated that the site was occupied during both early Late Woodland and late Late Woodland time ranges. Analysis of the ceramic assemblages and attributes from these dated contexts might be used to further document the differences between early and late Late Woodland ceramic styles and technology.

Table 37 shows the descriptive attributes of the ceramic assemblages by provenience unit at Sadie's Cave. All ceramic artifacts were recovered from the late Holocene Strata Set A, with the exception of two sherds recovered from mixed A/B contexts (TU2/L4). Identification of any ceramic variation within the Late Woodland period will need to rely on the finer stratigraphic divisions of the specific proveniences and levels to differentiate potential early and late subassemblages.

Table 37. Ceramic Artifacts from Sadie's Cave Grouped by Descriptive Category and Provenience.

Provenience	Maramec Cordmarked	Maramec Plain	Shell and Dolomite/ Cordmarked	Shell and Dolomite/ Fabric-marked	Shell and Dolomite/ Plain	Rounded Sand/ Plain	Dolomite-Rounded Sand/ CordmarkedTotal
Surface	10(1)	1	1				113
Test Unit 4/5							
Stratum 1			1				1
Stratum 2A	1						1
Test Unit 2/6							
Stratum 1A/Level 1					1		1
Stratum 1/F112			1				1
Stratum 1B/Level 2		1	1			1[c]	3
Level 4			1[a]			1	2
Test Unit 3							
Stratum 1/Level 1		2(1)		5(2)	2(1)[b]		110
Stratum 1/Level 2	2			1			3
Stratum 1/Feature 4	1						1
Test Unit 7							
Stratum 1/Level 1	2	2	1	1			17
Stratum 1/Disturbed?	1(1)			1			2
Total	**17(2)**	**6(1)**	**6**	**8(2)**	**3(1)**	**2**	**345**

Note: Sherds from general excavation matrix and from flotation samples (> ¼") have been combined. Rim sherds are noted in parentheses.

[a] Surface is eroded or missing, possibly cordmarked prior to damage
[b] Rim has shell, dolomite, and fine rounded sand as tempering agents
[c] Plain, burnished exterior surface has remnants of three broad incised trails

Regarding possible temporal variability, radiocarbon assays of 950 B.P. were obtained on material derived from TU5/Level 1 and TU7/Level 1. Assays dating between 1400 and 1700 B.P. were obtained from TU5/Level 3 (Stratum 2A), TU5/Feature 8 (Stratum 2B), and TU2/Level 2 (Stratum 1B) proveniences. This sequence within the Strata Set A samples suggests that there should be vertical, provenience-based separation of potentially earlier and later technological or stylistic variations within this general Late Woodland depositional unit. Shell tempering, red-slipped surfaces, bowl forms or other indicators of later technological or stylistic trends should be associated with the uppermost levels in each test unit, while the lower levels within Strata Set A should contain the more ubiquitous Maramec Plain and Maramec Cordmarked sherds with no evidence of temper or stylistic elaborations.

Unfortunately, the single test unit with the best stratigraphic separation of dates (TU4/5) produced the least number of sherds. However, the single shell-tempered sherd from TU4/5 was associated with the later date, and the lower levels produced a single Maramec Cordmarked sherd. The trends within TU2/6 are not very clear cut, and the analyses are again hampered by small sample sizes. Level 2, with a radiocarbon assay of 1670 B.P., produced Maramec Plain and shell-dolomite cordmarked sherds as well as one burnished-surface, broad-trailed sherd tempered with a combination of rounded sand and crushed chert. This latter sherd may be nonlocal in origin or may indicate contact and exchange with more southern Caddoan groups during the Late Woodland, since broadly trailed plain/burnished surfaces are found on Late Woodland (Baytown) sherd varieties to the south and east of the Ozark Highlands. The TU2/L4 sherds are also technologically mixed, consisting of an eroded shell/dolomite-tempered sherd and another rounded sand-tempered/plain-surface sherd that may be associated with nonlocal ceramic technologies.

The assemblage from Test Unit 3 is the largest of any test unit, and it shows some interesting trends. Maramec Plain is present only in the uppermost level, while Maramec Cordmarked is present in the second level and the associated Feature 4 contexts. The upper level also includes five of the six examples of shell/dolomite-tempered, fabric-marked sherds and both shell/dolomite-tempered, plain sherds. This suggests that the use of shell as a tempering agent and creation of fabric-marked sherds are both late additions to the ceramic technology repertoire. Similar sherds had been recovered from Stratum 1 at 23PU265, but these were associated with a relatively mixed ceramic assemblage that was poorly dated. Test Unit 3 Stratum 1 has no associated radiocarbon dates, but the expected ceramic technological and stylistic trends are present.

The Test Unit 7 assemblage apparently contains a mixture of both early and late ceramic attributes. This finding is not surprising, since the overall stratigraphic sequence becomes increasingly compressed toward the west.

Only six rim sherds were recovered from the combined 1993 and 1994 investigations. One of these was recovered from the surface in the western third of the cave during the 1992 Phase II testing. It is too small to orient with certainty, but is probably part of a Maramec Cordmarked jar. Another small rim fragment of a Maramec Cordmarked vessel was recovered from TU7/Level 1 from disturbed (rodent burrow) contexts. The other four rims were recovered from TU3/Level 1. One is a small fragment of a Maramec Plain jar (?) with an outcurving rim and rounded lip (not illustrated). Another rim (not illustrated) is from a shell/dolomite-tempered vessel of unknown form; it has a rolled rim and flattened lip. The last two rim sherds are from shell/dolomite-tempered, fabric-marked vessels. One (Figure 50a) is a probable bowl fragment with a flattened lip that is

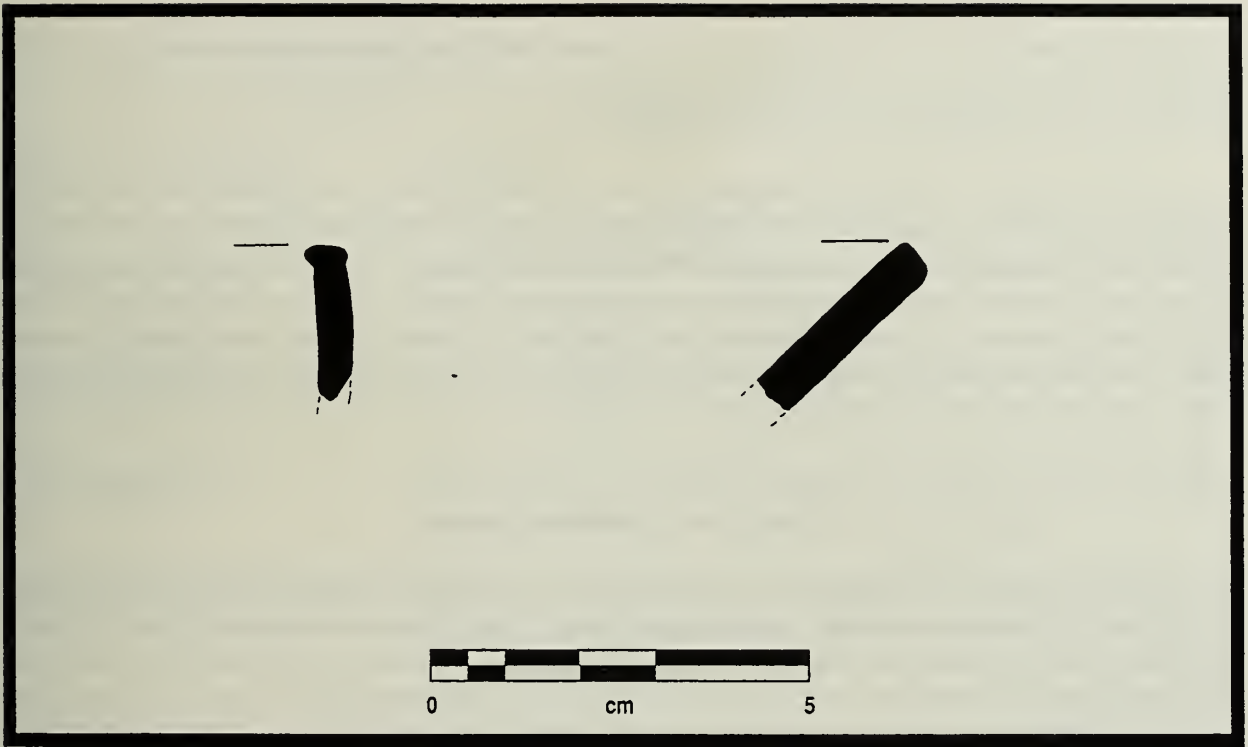


Figure 50. Sadie's Cave Test Rim Sherd Profiles. a) fabric-marked bowl (?); b) cord-marked and fabric-marked shallow bowl or pan. Both are from Test Unit 3/Level 1 provenience.

slightly T-shaped (Joukowsky 1980:352). Fabric-marking continues to the lip, and the estimated orifice diameter is 18 cm. The other sherd is of interest in that it apparently represents the rim of a shallow bowl or pan that has a combination of S- and Z-twist cordmarking and fabric-marking to its rolled lip (Figure 50b). It has an estimated orifice diameter of 26+ cm. This specimen represents the only known fragment of a pan recovered from Ozark archaeological contexts, and suggests that the fabric-marking and use of shell either alone or with other tempering agents is a late development in the ceramic temporal sequence of the region. It also suggests some degree of contact with nonlocal groups; pan vessel forms are increasingly common in Mississippian and later Caddoan assemblages after about A.D. 1000 (Brown 1984; Chapman 1980).

In summary, the trends in ceramic technology, stylistic attributes and vessel form observed in the Sadie's Cave assemblage indicate that there are probably at least two occupations of the site that took place within the Late Woodland period. The earlier occupation(s) are associated with production/use of Maramec Cordmarked and probably Maramec Plain ceramics, both of which are tempered only with crushed dolomite. Later occupation at about A.D. 1000 or so resulted in deposition of more sherds that exhibit a greater variety in vessel form, surface treatment, and tempering. Fabric-marked exterior surfaces are found on several sherds, at least one of which probably represents a shallow bowl or pan vessel form. Shell is commonly used as a tempering agent, most often in combination with other ingredients such as fine rounded sand and crushed dolomite. Jar forms are present throughout the sequence. These findings join a growing body of evidence that supports segregation of the Late Woodland Maramec Spring Phase into at least early

and late manifestations. The later portion of the phase would span the time from about A.D. 1000 to 1500, and is identified by the attributes noted above and others that indicate regional interaction with nonlocal Mississippian and/or Caddoan groups.

The search for a Middle Woodland ceramic assemblage on Fort Leonard Wood remains unfulfilled. However, recovery of a plain/burnished-surface sherd tempered with an unusual combination of rounded sand and crushed chert from the lowest pottery-bearing level at the site suggests either contact with nonlocal ceramic technology or evidence of the very initial stages of the introduction of ceramic technology into the Ozark Highlands. Obviously, much more work is needed before pre-Late Woodland ceramic technology can be either identified or eliminated from consideration in the local cultural sequence.

Analysis of Lithic Debitage

Following standard analytical procedures used in previous projects at Fort Leonard Wood, the lithic artifacts were divided into a series of debitage types reflecting sequential stages of bifacial tool manufacture and use (see Table 38). The analytical scheme is a modified version of lithic technological analysis methods developed by Collins (1975), Crabtree (1972), Johnson (1981), and Johnson and Morrow (1987), which have been adapted and modified by Ahler (1981, 1984, 1986b) for analysis of other assemblages derived from rock shelters in the midcontinental area. Ahler further adapted this general analytical model to be specifically applied to assemblages from Fort Leonard Wood (Ahler and McDowell 1993; Ahler et al. 1995).

The debitage types used in this analysis represent a bifacial reduction trajectory (BRT), and reflect the observation that almost all formal chipped-stone tools observed to date in assemblages from Fort Leonard Wood and the Ozark region are bifacial. The predominance of bifacial formal tools implies that a bifacial, lithic-reduction technology was used in their manufacture and that it is appropriate to use an analytical scheme based on BRT for classification and analysis of debitage flake types as well as formal tools. Unifacial tools, cores and ground-stone tools are also present in minor proportions in the assemblages, and these tool categories are recognized and described separately (Table 38).

In the bifacial reduction trajectory sequence used here, primary and secondary flakes show evidence of removal from cores in early stages of manufacture by the type of platform and amount of cortex present. Tertiary and bifacial thinning flakes represent later stages of the reduction sequence and are associated with biface shaping, hafting and maintenance. Tertiary flakes are somewhat problematic in this analysis, since these flakes could be produced through several different reduction trajectories, including unifacial-tool blank production, blade production and general core-flake technology that results in production of large flakes for use as expedient unifacial tools (see Ahler 1993; Koldehoff 1987). However, systematic production of these other end-products of lithic reduction has not been observed in Fort Leonard Wood assemblages. Consequently, the assumption is made for analytical purposes that tertiary flakes represent the by-product of intermediate-stage reduction in a bifacial reduction sequence.

The most common non-BRT debitage categories are broken flakes and angular shatter, both of which may be produced through several types of lithic reduction activities, including bifacial

Table 38. Lithic Debitage Category Descriptions.

Category (Abbreviation)	Description
Primary flake (Prim)	Flake with large bulb of percussion, flat platform, and >50% cortex on dorsal surface
Secondary flake (Sec)	Flake with large bulb of percussion, flat platform, and <50% cortex on dorsal surface
Tertiary flake (Ter)	Flake with flat, unfaceted platform, no cortex on dorsal surface, and evidence of two or more prior flake removals
Bifacial thinning flake (BTF)	Flake with small, diffuse bulb of percussion, faceted platform, lip at juncture of platform and ventral surface, no cortex, and evidence of two or more prior flake removals on dorsal surface
Broken flake (BF)	Generally flat flake fragments that lack a striking platform and have no cortex
Block shatter (Shat)	Angular pieces that are probably cultural in origin, but lack flake characteristics
Bipolar flake (BP)	Flakes that show evidence of manufacture through bipolar technique. Attributes are variable, but all indicate use of large amounts of relatively uncontrolled force in the manufacturing process. These may include presence of two platforms at opposing ends of the flake, crushing on one or both platforms, large ripple marks, highly convoluted ventral flake surfaces, and longitudinal splitting of the flake into columnar or prismatic sections.
Blade (Blade)	A thin tertiary flake which is at least twice as long as it is wide and shows parallel to subparallel dorsal flake scars indicative of systematic removal of similarly shaped flakes. Ground or prepared platforms often indicate systematic and intentional production of multiple blades from a single core.

reduction. Broken flakes are considered to be those flakes which lack a platform or other attributes that would permit their placement into one of the more definitive debitage categories in the BRT. Flakes that had no platform but which had cortex on the dorsal surface were accordingly classified as primary or secondary flakes, depending on the amount of cortex present. Angular shatter fragments are interpreted as being of cultural origin, but they lack attributes that would permit their

classification as a specific flake type. Noncultural chert was not included in the angular shatter category.

Other types of debitage that do not fit a bifacial reduction sequence were noted when encountered, though these are rare occurrences. Occasionally small unifacial blades (Montet-White 1968) were observed, which are flake types usually associated with a specialized type of unifacial flake production industry. Such industries are known to be associated with both Paleoindian and Middle Woodland temporal periods. Consequently, blades and blade-like flakes were tabulated to determine if these flake types were present in any particular stratigraphic subassemblage. However, the blade cores and platform rejuvenation flakes that are also associated with a systematic blade industry were not present in the assemblages. Long, thin flakes may be produced in small numbers as minor by-products in any lithic reduction trajectory, so their occasional presence in an assemblage is not particularly noteworthy.

Little evidence was found of bipolar flakes or bipolar cores, which is not surprising given the abundance, large size and generally high quality of chert raw material in the Fort Leonard Wood area. Bipolar industries are usually found in areas with variable-quality raw material in the form of small nodules (see Ahler et al. 1988; Binford and Quimby 1963; McPherron 1967). In addition, studies by Ahler (1987) and Ahler and Christensen (1983) indicate that flakes with attributes indicative of bipolar reduction techniques are present in low proportions in all assemblages. This pattern was observed even in experimentally produced debitage assemblages which excluded bipolar manufacturing techniques. Jeske and Lurie (1983) have demonstrated that while individual specimens are difficult to identify as bipolar flakes, the use of a bipolar flaking technique is more easily identified by comparison of ranges of variation in larger samples of flakes. For these reasons, the mere presence of an occasional bipolar flake in an assemblage is not interpreted as evidence for bipolar reduction as a systematic or common manufacturing technique. At least five percent of the debitage assemblage should be identified as bipolar in order to make this type of inference. As with the other reduction techniques discussed above, the modified item assemblage should also be used to confirm the use of bipolar reduction. Bipolar cores or *pièces esquilées* should be present if bipolar reduction is routinely practiced. Bipolar flakes were tabulated when observed to determine if systematic bipolar reduction strategies were associated with any particular occupation of the site.

All lithic material was classified into the above eight debitage categories by the primary author and Ilona Matkovski, a graduate student with prior experience in lithic debitage analyses. All debitage classifications were spot-checked to establish consistency between the analysts. In these analyses, utilized flakes were counted like any other flake type and were included in the appropriate debitage category. These expedient tools were then separated from the remainder of the debitage for later detailed analysis as modified items. They are not identified individually in the debitage tables presented below.

In addition to the flake type classification, other observations were made for each provenience analyzed. Estimates were made of the percentage of heat-treated material present in each provenience, based on attributes such as discoloration to a red or pink hue and presence of a waxy to glossy surface luster. In addition, a general material type analysis was performed that separated locally available chert (derived from Roubidoux, Gasconade and Jefferson City/Cotter Ordovician formations) and locally available orthoquartzite (Roubidoux formation) from nonlocal sources such as Mississippian-age Burlington chert and other raw material types not available within the immediate

vicinity of Fort Leonard Wood. Finally, during the course of the analysis, fragments of noncultural chert were counted and discarded. These materials are not included in the tabulations presented below, though they may have been included in the initial tabulation and sorting forms as possible lithic debitage.

Some general observations on the debitage attributes can be noted. First, the proportion of heat-treated chert is almost always between 10 and 30 percent of each provenience-based subassemblage. Only a few proveniences have more than 30 percent heat-treated chert, and these are often from feature contexts which probably indicates postdepositional heating of chert rather than changes in the overall strategy of lithic tool production. Likewise, only a few proveniences had no heat-treated chert present. Heat treatment of chert appears to have been a consistent and regular aspect of lithic tool production strategies during all time periods represented in Sadie's Cave. The incidence of heat treatment does not appear to have changed significantly through time.

Regarding raw material type trends, Roubidoux orthoquartzite appears to be a consistent, but minor, contributor to the lithic debitage assemblage. Its greatest abundance is evident in the TU5/S3-5, TU2/S3, and TU2/F2 analytical units, where it makes up between three and five percent of the assemblage. Other units exhibit lower proportions, and it is almost absent from the analytical units that comprise Strata Set A. Its use thus appears to have decreased through time. The overall incidence of nonlocal raw material types is very low in all analytical units. Burlington chert is extremely rare in the debitage, but is slightly more frequent in the modified item assemblage. These observations suggest that nonlocal materials are not being imported into the Sadie's Cave in unfinished or unreduced forms. If nonlocal material is present at all, it tends to occur in the form of discarded finished tools. Systematic exchange of nonlocal lithic raw material is not indicated at any time period in the Sadie's Cave assemblages.

Table 39 shows the distribution of debitage recovered from ¼-inch screened excavation samples by debitage type for all excavation-based analytical units. Material from both the 1993 Phase II testing and the 1994 excavations have been combined in this presentation. Several additional trends can be extracted from these data that shed light on the types and range of lithic reduction/production activities that were carried out during different occupational episodes.

First, blades are present mainly in the upper analytical units of the test units. This finding suggests that systematic blade production technology may be part of the early Late Woodland or Late Prehistoric lithic reduction strategies. Blade production has often been interpreted as indicative of some degree of participation in the pan-regional Middle Woodland ceremonial/ideological system known as the Hopewell Interaction Sphere (Seeman 1979), and several researchers have used the presence of small blades as a tentative indicator of Middle Woodland temporal affiliation. The Sadie's Cave debitage data lends some credence to this temporal trend, but much more control over both chronology and assemblage composition is needed before a Middle Woodland blade technology can be attributed to the Ozark Highland region.

Test Unit 2/6 has much more abundant debitage than any other test unit location, and this observation seems to hold for all temporal assemblages. This finding suggests that the TU2/6 area may have been used consistently through time as either a lithic reduction/tool maintenance area or for disposal of debitage that had been cleaned from other portions of the cave floor. This latter interpretation is consistent with observations of higher ash content in all strata near the edge of the

Table 39. Distribution of Debitage Categories by Analytical Unit within Sadie's Cave.

Analytical Unit	Debitage Category PRIM	SEC	TERT	BTF	BF	BP	Blade	SHAT	TOTAL
TU5/S1	3	10	33	13	57		3	22	141
TU5/S2	2	7	49	15	82	1	1	27	184
TU5/L4		2	13	3	17			3	38
TU5/S3–5	4	18	32	25	105	1	1	77	270
TU5/L11	1	4	7	2	6	2		14	36
TU5/S7		4	15	3	32	1		18	73
TU5/S8		1			2			3	6
TU5/F101			5		5			2	12
TU5/F3		2	2	1	8			6	19
TU5/F9			1		1			1	3
TU2/S1	10	30	203	58	285	1	3	132	722
TU2/L4	2	12	100	5	138			25	282
TU2/S2	1	19	42	8	87	4		64	225
TU2/S3	4	15	56	12	71	3	1	82	244
TU2/S5	1	6	4	2	12	1		20	46
TU2/S7									0
TU2/F2	6	16	28	12	51	5		56	174
TU3/S1	5	8	42	5	35			19	114
TU3/L3	2	1	4	1	5	1		9	24
TU3/S2	1	1	21	3	25	1		13	65
TU3/S3	1		6	2	10			11	30
TU3/L7				1	1				2
TU7/S1	1	4	28	3	13		2	8	61
TU7/L2	2	2	20	5	21			38	89
TU7/S3		1	10		19		1	7	38
TU7/S4		3			2			3	8
TU1/S1		1	1		2				4
TU1/S2–4	1		3		5				9

Note: Only material recovered from ¼-inch screened general excavation matrix is included. Abbreviations for debitage categories follow those shown in Table 38.

drainage depression at the south wall of the cave. This low area may have been used as a refuse disposal area during many of the individual occupation episodes, resulting in accumulation of more debris compared to other exposures of contemporary strata.

Regardless of the fluctuations in the frequency of debitage across the space within Sadie's Cave, the impression from the debitage profiles is that all occupations represent generalized bifacial

reduction sequences. Almost all BRT flake types are represented in all analytical units, and the proportions are indicative of a mixture of early-stage and late-stage biface production and biface maintenance. Such generalized debitage profiles are consistent with short-term use of the site for residential encampments. However, there are some trends through time and across space that bear a closer examination and lend additional dimensions to the interpretation of the lithic reduction activities at Sadie's Cave.

More detailed technological examination of the debitage types can shed light on the types of lithic reduction trajectories employed by inhabitants of Sadie's Cave at different time periods. Identification of the methods and stages of lithic manufacturing activities in each component is an important step in determining the role of the site in the local settlement system, how the site function may have changed through time, and the potential relationship of Sadie's Cave occupations to other contemporary sites in the area.

Since production of bifacial lithic tools is a reductive process that is often carried out in discrete stages, the resulting debitage can be discriminated into specific flake types that have attributes indicative of specific reduction stages (see Callahan 1979; Collins 1975). Presence of a wide range of bifacial reduction flake types in an assemblage indicates a more complete reduction sequence, from initial raw material testing to final shaping and maintenance of the finished product. Presence of a narrow range of flake types indicates an emphasis on certain portions of the manufacture and maintenance sequence. Patterns of bifacial reduction are also affected by the duration and intensity of occupational episodes. Comparisons between flake types and the reduction stages of modified items should indicate the same range of lithic manufacturing activities. However, since modified items may have been curated and removed from their original location of use or manufacture (Binford 1979, 1982; Kelly 1983), debitage analysis provides a more reliable indicator of the range of lithic manufacturing activities that took place during a specific occupation episode.

Based on these flake categories, the following debitage profiles might be expected:

1) Initial testing and reduction of raw materials should result in large numbers of primary and secondary flakes, angular fragments, thick or crude bifaces, and cores (including tested cores);

2) Late-stage reduction of bifaces should produce very high proportions of tertiary and bifacial thinning flakes. Bifaces broken in manufacture, thin bifaces and formal tools should be part of the modified item assemblage;

3) A generalized lithic reduction sequence should be represented by all flake types in the BRT suite. Proportions of tertiary and bifacial thinning flakes should be higher than the proportions of initial stage flakes, because more flakes are produced as the reduction sequence runs its course. Bifaces in all stages of manufacture should be present in the modified item assemblage.

The data presented in Table 39 indicate that all strata show an increase in the proportion of flakes from early to later stages of reduction in the BRT, indicating that most lithic reduction activities involved late-stage manufacture and maintenance of bifacial tools. This pattern corresponds well with the expectations of a generalized suite of bifacial reduction activities, and is supported by

recovery of bifaces representing early, intermediate, late, and finished stages of manufacture (see next section). These data also indicate that late-stage reduction was more common than early-stage reduction.

Debitage profiles were constructed by calculating the cumulative proportions flake types represented in each stratum. For comparison, only the first four flake types (primary, secondary, tertiary, and BTF) and the broken flake category were considered in the flake total for each analytical unit. This truncation permits comparison of most of each assemblage, and eliminates any biases that might be introduced through inclusion of blade technology, bipolar reduction, and potentially naturally fractured chert in the comparison. Table 40 shows the cumulative proportions of these selected flake types in the BRT. Comparison of assemblages is facilitated by application of the Kolmogorov-Smirnov two-sample statistical inferential test.

The K-S two-sample test (Thomas 1976) is designed to compare two series of ordinally ranked data. The maximum differences in cumulative proportions at each stage in the ordinal sequence are compared to a critical value, which is calculated from a modified proportional reduction in error formula. If the observed maximum difference in cumulative proportion exceeds the calculated critical value, this indicates that the two series are significantly different in terms of the ordinal scale used in the comparison (in this case, debitage types). For these comparisons, a level of rejection of 0.1 was used to calculate the critical value for each test. Analytical units with less than 20 flakes were not compared because of the effects of small sample sizes.

Each analytical unit was compared to all other analytical units in the same test unit using the K-S two sample test as described above. Though there are obvious differences in the proportions of flake types represented in these analytical units, only one pair-based comparison resulted in determination of significant differences in debitage profiles. Comparison of Test Unit 7 Stratum 1 with Stratum 3 shows significantly greater proportions of tertiary and bifacial thinning flakes in the upper stratum. This finding suggests a shift toward more late-stage biface reduction associated with the Late Woodland occupations sampled in this test unit.

Another series of K-S tests was run that compared broadly contemporary samples (as indicated by strata set assignment) derived from different test units. This series was performed to determine if there were likely to be particular spatially definable areas within the cave where particular stages of lithic reduction were performed. These comparisons showed that for the Strata Set A analytical units, there are significant differences between the assemblages represented in TU3 and TU7 and those present in TU2 and TU5. The units farther into the cave show significantly higher proportions of late-stage flake types (tertiary and BTF) compared to the units nearer the mouth of the cave. This spatial difference suggests that the portions of the cave farther from the mouth were used systematically for late-stage lithic reduction activities during the Late Woodland occupations.

Comparison of the Strata Set B subassemblages from each test unit showed no significant differences. All spatial samples of the Late Archaic occupations indicate generalized lithic reduction activities that are consistent with a series of short-term, domestic/residential occupations of the site during this time span. Comparison of the two exposures of Strata Set C (TU2 and TU5) also showed no significant differences in debitage profiles. Again, short-term generalized residential occupations are indicated for this time span.

Table 40. Relative Proportion of Flake Types in the BRT for Analytical Units at Sadie's Cave.

Analytical Unit and (Strata Set)	PRIM	SEC	TER	BTF	BF	Total
TU5/S1 (A)	0.026	0.112	0.397	0.509	1.000	116
TU5/S2 (A)	0.013	0.058	0.374	0.471	1.000	155
TU5/L4 (A/B)	0.000	0.057	0.429	0.514	1.000	35
TU5/S3–5 (B)	0.021	0.115	0.319	0.450	1.000	191
TU5/S7 (C)	0.000	0.074	0.352	0.407	1.000	54
TU5/S8 (E)	0.000	0.333	0.333	0.333	1.000	3
TU2/S1 (A)	0.017	0.068	0.415	0.514	1.000	586
TU2/L4 (A/B)	0.008	0.049	0.444	0.463	1.000	257
TU2/S2 (B)	0.006	0.127	0.395	0.446	1.000	157
TU2/S3 (C)	0.025	0.120	0.475	0.551	1.000	158
TU2/S5 (D)	0.040	0.280	0.444	0.520	1.000	25
TU2/S7 (E)	---	---	---	---	---	0
TU3/S1 (A)	0.053	0.137	0.579	0.632	1.000	95
TU3/L3 (A/B)	0.143	0.214	0.500	0.571	1.000	14
TU3/S2 (B)	0.020	0.039	0.451	0.510	1.000	51
TU3/S3 (B)	0.053	0.053	0.368	0.474	1.000	19
TU3/L7 (E)	0.000	0.000	0.000	0.500	1.000	2
TU7/S1 (A)	0.020	0.098	0.647	0.706	1.000	51
TU7/L2 (A/B)	0.039	0.078	0.470	0.588	1.000	51
TU7/S3 (B)	0.000	0.033	0.367	0.367	1.000	30
TU7/S4 (E)	0.000	0.600	0.600	0.600	1.000	5

Note: Data presented in Table 39 were used to construct the proportions; feature-based analytical units are omitted due to small sample sizes.

Finally, the combined debitage profiles for each Strata Set were compared with each other in another series of K-S two-sample tests. These tests indicated that the debitage profile of Strata Set A was significantly different from the profile of the underlying Strata Set B. Again, greater proportions of bifacial thinning flakes indicate that during the Late Woodland occupations, the lithic reduction activities focused increasingly on late-stage reduction, tool maintenance, or other activities that resulted in production of high proportions of late-stage reduction flakes. No other significant differences were found, which may be due partially to the effects of sample sizes on the calculation of K-S test critical values.

These trends imply that the function of the site in the local settlement system may have changed. Chert quality, group mobility and site function all affect raw material exploitation patterns and reduction strategies. In addition, the interpretations presented here must be tempered by the

realization that each analytical unit and strata set includes a composite of several individual occupation episodes. Still, these data suggest that the function of the site may have changed during the Late Woodland (Strata Set A) occupations to reflect a more specialized subset of the settlement system. Instead of generalized short-term domestic habitation as indicated in all earlier strata sets, the Late Woodland inhabitants carried out late-stage lithic reduction activities with greater frequency. This observation suggests use of the site in a more specialized manner, perhaps as a field camp where activities focused on retooling and resharpening of used or broken tools or as a more specialized site where bifaces were shaped and fashioned into their final form. The generally low numbers of debitage are not indicative of an actual workshop site whose primary function was final reduction and shaping of bifaces that had been initially reduced elsewhere. Additional inferences regarding the range of activities associate with each strata set may be gleaned from examination of lithic debitage recovered from flotation samples.

Lithic debitage from the heavy fraction of flotation samples was also analyzed using the same debitage and modified item classification scheme applied to the general screened assemblage. Because the heavy fraction was collected using a 1-mm mesh size, these samples should contain a higher proportion of the small late-stage reduction flakes than would be recovered from the ¼-inch screen samples from general excavation contexts. These differences in screen biases and sample volume demand that the flotation and general matrix samples be kept separate; they cannot be combined into a single sample from each provenience. In addition, the small sample volumes and sample sizes restrict analysis by analytical unit or individual proveniences. However, the composite assemblages for each strata set are of sufficient size to warrant statistical comparison.

Table 41 presents the distribution of debitage types by strata set. Flotations taken from features have been included in the table, and were assigned to the appropriate strata set with which they are associated. These data indicate that a higher proportion of BTF were recovered in flotation samples than in the general screen matrix samples. This is not surprising, since many BTF result from tool resharpening or final shaping of finished formal tools, and these activities generally result in production of very small flakes. However, broken flakes are still the most numerous debitage category, which is also to be expected given the highly fragmentary nature of the small debitage.

Comparison of the strata set debitage profiles was effected using the same flake type sequence and statistical tests as applied to the general screened sample. The general trend in the assemblages is for increasing proportions of BTF to be present in the later strata sets; Strata Set A has the highest proportion. Secondary flakes are found in greater proportions in strata sets B, C and D. However, statistical comparison of the assemblages using the K-S two sample test described above indicates no significant differences in the assemblages at the 0.10 level of rejection.

The debitage analyses presented above indicate three major trends in lithic reduction activities in the Sadie's Cave occupations. First, the high density of material in the TU2/6 location suggests that this was an area where lithic debitage and other refuse were discarded. This location seems to have been consistently used for refuse disposal during all major temporal periods represented. This interpretation is supported in part by the sloping strata, which indicate that the drainage depression at the south side of the cave has been a consistent feature of the cave interior throughout the Holocene, affecting both natural taphonomic processes such as drainage and sedimentation as well as cultural processes such as the spatial location of activity and refuse disposal areas.

Table 41. Distribution of Debitage Categories by Strata Set.

				Debitage Category					
Strata Set	PRIM	SEC	TERT	BTF	BF	BP	Blade	SHAT	TOTAL
A	1	27	91	141	368	2		121	751
A/B		5	22	18	76			24	145
B	1	26	80	94	225			101	528
C		20	24	28	81	1	1	39	194
D+F2		5	11	10	45	1		14	85
E		3	7	5	15			10	40
F									0

Note: Only debitage derived from heavy fraction flotation samples is included. Abbreviations follow those shown in Table 38.

Second, the lithic debitage profiles and generally low density of material for strata sets B-E suggest occasional use of the cave for general domestic habitation. A wide range of debitage types are represented, and while late-stage flake types are more common, there is no clear domination of these assemblages by any single flake type. The low density of materials is consistent with earlier interpretations of the strata and general material classes that stressed that each strata set included the remains of multiple short-term occupation episodes. No single occupation episode is evident, and the site probably never functioned as a base camp in the local settlement system.

Finally, the assemblage from Strata Set A shows clear statistical differences in debitage profiles when compared with earlier occupations. This assemblage is dominated by late-stage tertiary and bifacial thinning flakes, and the overall density of debitage is much higher than in previous strata. This combination of attributes suggests that the site was used more intensively or more frequently during the Late Woodland period, and that the range of activities carried out became more restricted. The site may have been used as a short-term habitation for a limited subset of the general population, who were perhaps engaged in more specialized activities. The increase in density of mussel shell and decrease in bone density, relative to earlier strata sets, supports this interpretation of a shift in site function during the Late Woodland period. This set of attributes conforms to what Binford (1980) describes as a field camp, a site type that is only associated with logistically organized settlement systems.

Several lines of evidence point to a change in site function during the Late Woodland Strata Set A occupation of the site, but little is known about the specific function of the site or the specific range of activities carried out during this time period or during earlier occupations. More detailed analyses of modified items provides additional and more direct information on the range and types of activities associated with each strata set, and should provide a more comprehensive interpretation of site function. These analyses are presented in the next section.

Analysis of Modified Items

Analysis of modified lithic and bone items, including formally shaped tools and minimally utilized specimens, provides data on the range and intensity of specific activities performed at the site, lithic procurement and reduction techniques, and changes in settlement and mobility strategies. Using this suite of data, inferences can be made regarding the probable roles the site played in the local settlement system and possible relationships of these occupations to contemporary assemblages. Modified items are artifacts that show evidence of marginal or surface alteration, either through use (utilized items) or through intentional shaping of the object (retouched or formal tools). Groundstone, chipped-stone and bone artifacts are included in the analysis.

The ultimate goal of the modified item analysis was to assess the function of site in the local settlement system; previous analyses indicated that the site function probably was not constant. Debitage , though abundant, can provide only limited information about the frequency and range of specific activities performed during a given occupational episode. Modified items exhibit more direct evidence of these specific activities, and attribute-oriented analyses can provide information on the techniques of lithic-tool manufacture, stages of reduction and the range of tasks being performed. Microscopic use-wear analysis of modified items can also provide data on specific activities, the kinetics of tool use and some characteristics of objective materials. All of these data are used to interpret the overall function of each strata set and analytical unit sampled at Sadie's Cave.

Two major types of hunter-gatherer settlement systems have been proposed by Binford (1980, 1982). Residentially mobile systems are composed of two site types—*residential camps* and *resource extraction locations*. Residential camps are usually occupied for short periods of time by a complete residential group. Resource extraction locations are occupied for very short periods of time by a limited subset of the residential group for the purpose of extracting or processing a specific resource.

Logistically organized systems have three types of sites. *Base camps* are occupied for extended periods of time by a large group of people. *Field camps* are the locus of specialized, intensive resource extraction and are usually occupied by a limited subset of the coresident base camp population. The people utilizing field camps may be limited to specific ages or sexes; field camp occupation may also be seasonal. *Resource extraction locations* are similar to those in residentially mobile systems.

These proposed settlement systems represent idealized, extreme examples that are at opposing ends of a theoretical settlement mobility continuum. In actual fact, reconstructions of archaeological settlement systems in the midcontinent often do not precisely replicate the theoretical models proposed by Binford, and often have attributes of both idealized settlement system types. Nevertheless, many prehistoric settlement systems exhibit attributes that indicate operation of a settlement system that is either more logistically or more residentially organized.

Archaeological signatures of specific site types are based largely on attributes that attempt to measure the duration and intensity of occupation and the range of activities performed. Indicators of the intensity or duration of occupation include densities of material classes, relative abundance of ash and charcoal, number and diversity of features, size and completeness of artifacts, evidence for tool curation, aspect and degree of modification, and stage of tool reduction. Artifact diversity is one of the best indicators of the range of activities performed by the resident group (Ahler 1981,

1984, 1986; Binford 1979, 1980, 1982; Carlson 1979; Kelly 1983; Winters 1969). Diversity can be evaluated using either descriptive typological or functional classification systems. When coupled with analyses that estimate the intensity (or relative intensity) of occupation, measures of assemblage diversity can be a powerful tool for assessing site function.

The idealized site types discussed above should be characterized by the following attributes (see also Ahler and Christensen 1983; Ahler 1984; Binford 1979, 1980, 1982; Carlson 1979; Kelly 1983; Richards 1982 for additional discussions of site type characteristics).

Residentially Mobile Organization .

Residential camps should exhibit low densities of cultural material, reflecting short occupation episodes. The diversity of artifacts is often moderately high; however, it may be quite variable because of changes in seasonality, duration of occupation, and differential rates of use and discard for different tool categories. Indicators of occupational intensity may also be variable.

Resource extraction locations have extremely low densities of artifacts, indicating minimal duration of occupations. Other indicators of occupational intensity or duration also are poorly expressed. Diversity is very low and the assemblage may be limited to a single type of artifact. Repeated visits to the same location may result in increased artifact diversity, but artifact density should still be very low.

Logistical Organization

Base camps exhibit high densities of cultural material, indicative of long periods of continuous occupation and/or occupation by larger groups. The diversity of artifacts is also high, reflecting a wide range of activities performed. Technological attributes that measure occupational intensity score high.

Field camps are not occupied for as long a period of time as base camps, but intensive use of the site may result in relatively high densities of material, evidence for production and use of specialized tools, tool curation or other indicators of intensive site use. Artifact density should be intermediate between base camps and residential camps. The diversity of artifacts should be less than base camps, and functional aspects of modified items should indicate the focus of the activities.

Locations should exhibit the lowest artifact density and diversity. The signature for this type of site is the same in both residentially and logistically organized systems.

Two dimensions of modified item attributes are analyzed in detail. The first dimension of analysis required classification of tools into descriptive typological categories for each assemblage, based on characteristics of the aspect, shape and degree of modification of the modified items. Technological variability within and among the assemblages, including information on artifact size and completeness, modification aspect, hafting modes, reduction stage, and patterns of tool curation, provide indirect measures of occupational intensity and duration. The second dimension of analysis entails examination of the diversity of activities represented in each of the analytical units and strata sets, and is approached through analysis of both the descriptive typological classification and

functional classification based on microscopic use-wear attributes. These two dimensions of modified item analysis are explored in this and the following section.

Descriptive Typology

The analytical sample of modified items consists of 165 specimens recovered from both general excavation screened samples and flotation samples. All potentially modified items were initially identified by macroscopic examination of surfaces and edges, resulting in segregation of utilized, retouched and formally shaped items. These potentially modified items were then examined under 10x magnification for evidence of recent (excavation-related) damage. Items with only recent damage were reintegrated into the debitage. Modified items from disturbed contexts such as rodent burrows were not included in the analysis.

The descriptive typology is based on a general classification system used for analysis of materials excavated recovered from both systematic surface collections and excavated assemblages from Fort Leonard Wood (see Ahler and McDowell 1993; Ahler et al. 1995). This typology was designed to focus on descriptive artifact attributes instead of implied functional characteristics. Functional connotations for some descriptive category names cannot be avoided, but current interpretations are based solely on the descriptive aspects of the items. An explicitly functional analysis of the artifacts is presented in the following section.

Terminology and definitions for descriptive tool categories are presented in Table 42. These categories are based on other modified item classification systems commonly used in the midcontinent (see Ahler 1971; Kay 1980; Wood and McMillan 1976). Incorporated in this descriptive typology are attributes that help assess other attributes of the artifact, including reduction stage, potential or actual tool curation and overall lithic technology. These aspects of the modified item assemblages are also examined. The descriptive classification uses the item, rather than the functional edge or "employable unit" (see Knudsen 1979), as the basis of analysis. Items with multiple working edges or surfaces are counted as single items, and separate categories are established for artifacts with multiple modified edges or surfaces.

The typology was constructed using combinations of three attributes. The initial attribute was the aspect of the modified item; tools were divided into major classes of unifaces, bifaces, cores, ground stone, and modified bone/antler. Within these five major classes, items were further categorized by the shape and relative degree of modification. A total of 25 descriptive tool categories comprises the present modified item classification system.

Unifacial artifacts are those with evidence of use or intentional shape or edge modification by removal of flakes from the margin of one aspect of the tool (dorsal or ventral). Two degrees of modification were recognized—marginal modification and overall shape modification. Items with only marginal modification, presumably derived from actual use of the tool, were placed in a single category of utilized flakes. Other intentionally modified and shaped unifaces were classified according to the shape of the modified area, the steepness of the working edge, presence or absence of a haft element, and its inferred function.

Bifacial artifacts show intentional flake removal from both dorsal and ventral aspects of the item. Bifacial items were divided into four categories on the basis of the degree of modification,

Table 42. Modified Item Category Descriptions.

Category (Abbreviation)	Description
Utilized flake (UF)	Utilized PRIM, SEC, TER, BTF, BF, BP, and ANG flakes that lack evidence of formal shaping or intentional retouch
Unifacial cutting tool (UCT)	Uniface with acute modified edge and evidence of overall shape modification; these items lack backing modification opposite the working edge
Backed knife (BKNIF)	Uniface with cortex or an intentionally snapped surface opposite an acutely angled modified edge, facilitating hafting or manual prehension
Burin (BUR)	Uniface with modification on short, thick projecting area(s), probably used as chisel-like tools for engraving or scoring hard material. The modification does not extend along the entire margin of the protrusion
Scraper (USCR)	Formally shaped uniface with a steeply angled working edge and no evidence for hafting; this category is often represented by fragmentary specimens only
Hafted end scraper (UHSCR)	Formally shaped uniface with a steeply angled working edge and evidence for hafting in the form of grinding or shaping of the margin opposite the steep working edge
Rough biface (RBIF)	Biface with only minimal modification
Thick biface fragment (TKBIF)	Biface that has been further reduced but still display sinuous margins and evidence of hard hammer percussion flaking
Thin biface fragment (tnbif)	Biface that has been fully thinned but lacks evidence of haft element modification
Projectile point/knife (PPK)	Fully reduced biface with evidence of a haft element. All projectile point/knives are included this single category, regardless of the style of hafting. Some bifaces show evidence of reworking into another tool form after breakage; these are discussed individually when encountered.
Arrow point (ARR)	Small, acuminate biface that shows evidence of use as a projectile but not as a more generalized projectile point/knife
Bifacial hafted scraper (BHSCR)	Biface with steeply angled working edge that shows evidence of hafting
Bifacial Perforator (BPERF)	Biface with elongated, acuminate working edge with shape modification along the entire elongate margin.
Bifacial Wedge (PE)	Rectanguloid biface with evidence of crushing on opposing edges, likely to have been used as a splitting wedge
Recycled biface (REC)	Biface recycled into another tool form (such as scraper or burin) after breakage or exhaustion of normal use-life

Table 42. Concluded.

Category (Abbreviation)	Description
Tested core (TCOR)	Block of raw material with only 1 or 2 flake scars
Core (CORE)	Block of raw material used for tool production, having at least 3 flake scars
Hammerstone (HAM)	Surficially use-modified item with flattened areas showing battering or crushing
Combination Mano/Hammerstone /Pitted cobble (COMB)	Surficially use-modified or intentionally shaped item with large flattened areas showing grinding, battered areas, and small battered depressions
Grinding Stone (GRND)	Surficially use-modified item with a single flattened area showing evidence of grinding
Flat Bone (BONE)	Flattened fragment of modified bone showing abrasion and polish on both surfaces
Cut Antler (ANT)	Antler segment with evidence of cutting and snap removal from larger beam, but no other modification
Antler Handle (HANDL)	Antler segment cut from beam and subsequently modified by drilling or surface shaping to form a handle for other tools
Antler Tine Flaker (TINE)	Antler tine cut from larger segment that also shows pitting and faceting of terminal end resulting from use, presumably as a pressure tool in flintknapping
Antler Billet (BILL)	Antler drift/beam segment with battered facets showing use as a percussion flaking tool in flintknapping
Bone Awl (AWL)	Bone that has been intentionally modified into a very sharp acuminate point, presumably for perforating soft materials

reflecting the stage of bifacial reduction (see Callahan 1979; Collins 1975; Johnson 1981; Johnson and Morrow 1987). These stages (rough biface, thick biface, thin biface, and projectile point/knife) are analogous to the stages represented in the bifacial reduction trajectory, though there is not a one-to-one correspondence of tool categories with debitage categories. In addition, several specific bifacial tool categories were constructed, again based on the shape of the modified area, the steepness of the working edge, presence or absence of a haft element, and the inferred function of the tool.

Cores are chert items that show evidence of flake production. Cores were divided into two categories reflecting the degree of use of the item. Tested cores (TCOR) show three or less flake removals; generally reduced cores (CORE) exhibit overall unsystematic flake removals.

Ground-stone tools are very rare (total n=4), and were separated into descriptive types reflecting the form and extent of surface modification. This resulted in definition of categories for

hammerstones, grinding stones, and a unique, formally shaped ground-stone tool used for a combination of grinding, edge-hammering, center-hammering, and pigment production.

Finally, modified bone and antler comprised the last major tool class, and consisted of six categories of intentionally cut, shaped, polished or battered faunal remains. These include undifferentiated cut antler fragments, antler handles, antler flaking tools (pressure flakers and percussion billets), bone perforators, and flattened modified bone fragments of unknown function. No modified shell was recognized in the initial examination of material from the site.

Table 43 shows the distribution of modified item categories by analytical unit. As with the debitage, Test Unit 2 has the highest number of modified items, accounting for 90 of the 165 modified items (54.5 percent). Twenty-six modified items were recovered from Feature 2 alone, including all but two of the modified bone and antler artifacts. Even disregarding the special assemblage of the Feature 2 grave goods, Test Unit 2 contained 64 of the 139 items recovered from general excavation contexts (46 percent). This high proportion of modified items supports the earlier interpretation that the Test Unit 2 area was used for refuse disposal throughout the use history of the cave.

Another observation is that both bifaces and unifaces are commonly represented in all strata, but cores are less common. Ground stone and modified bone/antler are rare; the latter are best represented in the Feature 2 grave goods assemblage. The low proportions of bone and ground stone artifacts in all modified item assemblages suggest that the occupational episodes of Sadie's Cave did not include the full range of domestic activities. This observation supports the earlier interpretation that all of the analytical units contain the remains of several short-term occupations, and further suggests that the nature of the occupations may have been more specialized, may have involved only a small subset of a residential group, or may be related to resource extraction activities rather than generalized habitation.

Utilized flakes are the most common tool category, and they account for 35.1 percent of the modified items. It is usual for utilized flakes to make up a high proportion of the modified item assemblage in Archaic components. Similar patterns were found at Modoc Rock Shelter in southwestern Illinois (Ahler 1981, 1986; Ahler et al. 1992). Formally shaped, unifacial tools are relatively rare at Sadie's Cave, accounting for only 6.7 percent of the modified items.

Bifaces that are part of the bifacial reduction trajectory (rough, thick, thin, and hafted bifaces) are the other major contributors to the modified item assemblage in each analytical unit. These four categories account for 36.4 percent of the modified items. However, the reduction stages are not equally represented; only one rough biface was recovered from the entire site assemblage. This trend suggests an emphasis on intermediate- and late-stage biface reduction, which supports the interpretation of a more limited or specialized function of the site throughout most of its occupational history. Intermediate and late-stage bifaces become even more common in the analytical units assigned to Strata Set A. This trend is particularly apparent in the TU3/S1 assemblage, which includes a cache of one rough and six thick bifaces in intermediate stages of reduction (Figure 51). Recovery of a cache of bifaces supports the previous interpretation of increasingly specialized use of the site during the Late Woodland time period. Perhaps the site functioned as a caching location or retooling station for population subsets engaged in resource extraction activities during this time period.

Table 43. Distribution of Modified Item Descriptive Morphological Categories by Analytical Unit at Sadie's Cave.

Analytical												Morphological Category Abbreviation														
Unit	UF	UCT	BKNIF	BUR	USCR	UHSCR	RBIF	TKBIF	tnbif	PPK	ARR	BHSCR	BPERF	PE	REC	TCOR	CORE	HAM	COMB	GRND	BONE	ANT	HANDL	TINE	BILL	AWL	TTL
TU5/S1	5	1							1																	7	
TU5/S2	2																2									4	
TU5/L4	3							1	1					1												6	
TU5/S3-5	5		1						1	2						1										10	
TU5/L11	1																									1	
TU5/S7														1												1	
TU5/S8																										0	
TU5/F6	1																									1	
TU2/S1	8		1			1		4	4	5						1										24	
TU2/L4										1							1									2	
TU2/S2	8	1						3	1							1	2				1					17	
TU2/S3	8		1	1				2	1	2							2	2								19	
TU2/S5	1								1																	2	
TU2/S7																										0	
TU2/F2	1	1						2	6			4	1				1		1			1	4	2	1	126	
TU3/S1	4						1	7	2	2																16	
TU3/L3	1										1															2	
TU3/S2	4	1			1					1																7	
TU3/S3	1								1																	2	
TU3/L7										1																1	
TU3/F4				1																						1	
TU7/S1								1							1		1				1					4	
TU7/L2	2							1	2																	5	
TU7/S3	3							2																		5	
TU7/S4										1										1						2	
TU7/S5																										0	
Total	58	4	3	2	1	1	1	23	21	15	1	4	1	2	1	3	9	2	1	1	2	1	4	2	1	1165	

Table 44. Distribution of Modified Item Descriptive Morphological Categories by Strata Set at Sadie's Cave.

Strata												Morphological Category Abbreviation														
Set	UF	UCT	BKNIF	BUR	USCR	UHSCR	RBIF	TKBIF	tnbif	PPK	ARR	BHSCR	BPERF	PE	REC	TCOR	CORE	HAM	COMB	GRND	BONE	ANT	HANDL	TINE	BILL	AWL	TTL
A	23	1	1	1		1	1	13	8	7				1	1	1	3				1					64	
A/B	3							1	2	1	1						1									9	
B	21	2	1		1			5	3	3						2	2				1					41	
B/C	1																									1	
C	8		1	1				2	1	2				1			2	2								20	
D	1								1																	2	
E										2										1						3	
F																										0	
Fea. 2	1	1						2	6			4	1				1		1			1	4	2	1	125	
Total	58	4	3	2	1	1	1	23	21	15	1	4	1	2	1	3	9	2	1	1	2	1	4	2	1	1165	

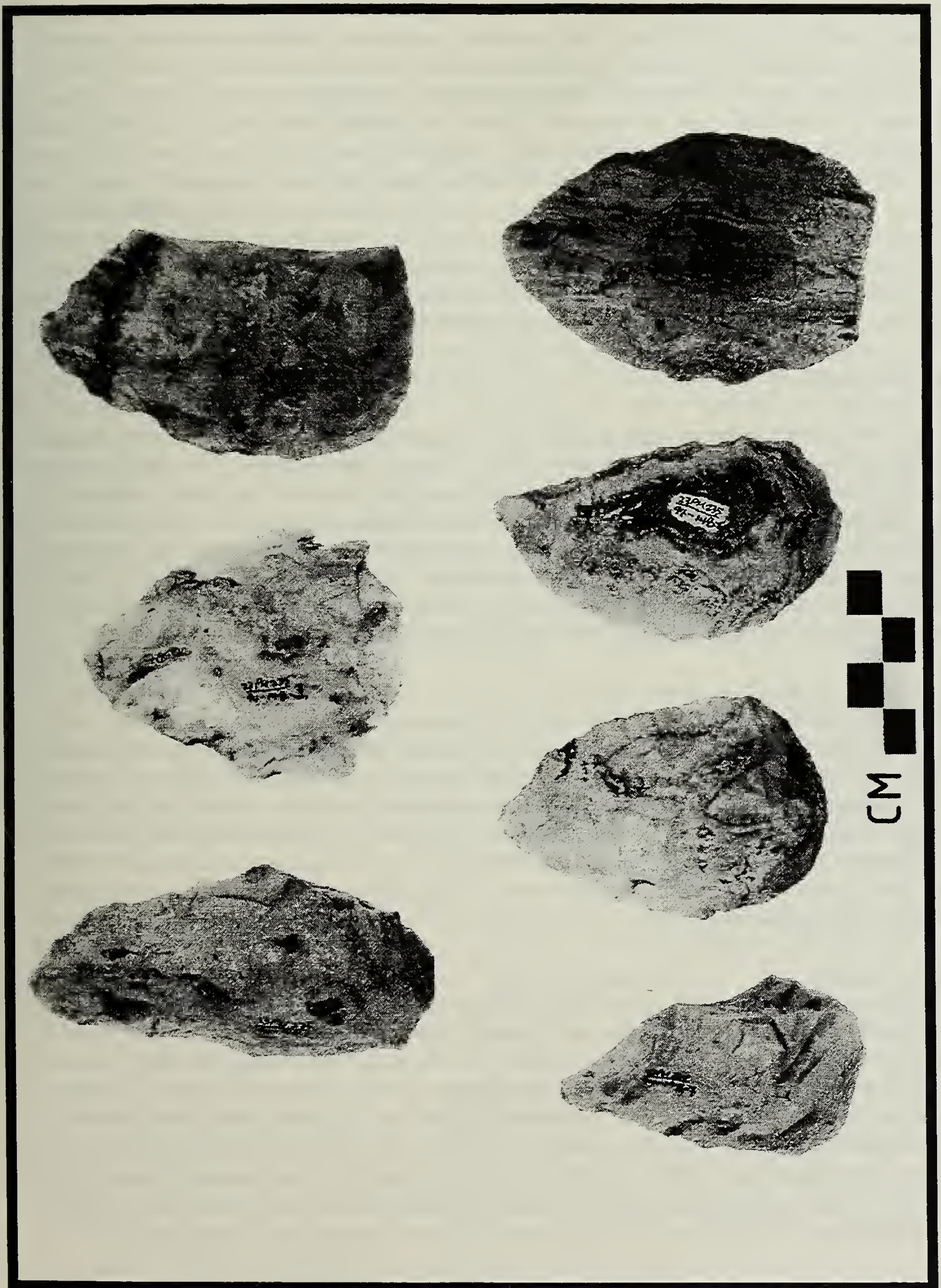


Figure 51. Cached Bifaces from Test Unit 3/Stratum 1 at Sadie's Cave.

Finally, it is clear from the data in Table 43 that the individual analytical units contain relatively low numbers of modified items. More detailed comparison of technological and functional attributes will be difficult due to the small sample sizes, and statistical comparisons will be particularly difficult to make. Accordingly, the modified item assemblages were combined based on the assignment of analytical units to previously defined strata sets (Table 44). This effectively increases the sample sizes of broadly contemporary occupations, and permits additional inferences to be drawn regarding the types and ranges of activities associated with each strata set. I realize that by combining individual occupations and analytical units across test units, it will be impossible to address the specific activities associated with any given episode of occupation. However, individual occupation episodes were not definable during excavation, so there will be little loss of data resolution. The following analyses based on strata set comparisons can at least provide data on broad temporal trends and general changes in settlement organization and site function through time.

Technological Analyses

Variation in technological aspects of stone tool production and use can be an important indicator of the duration, intensity and function of occupational episodes. In establishing a relationship between technology and site function, the assumption is made that under conditions of high group mobility, the duration of any given occupation episode will be short. During this short period of time, there will be less energy devoted to manufacture of formally shaped and potentially curated tools and more energy devoted to expedient use of items that require little overall shape modification and to curation of existing formal tools. If group mobility is low, these conditions and relationships should be reversed (see also Binford 1982; Kelly 1983).

Attributes of modified items used to assess the overall intensity of occupation include observations on the technology used in tool manufacture, modification aspect, hafting mode, reduction stage, and evidence of curation. Collectively, these attributes provide relative measures of the energy employed in tool manufacture, curation, and use. These attributes are assumed to be positively correlated with increasing occupational intensity or duration. In addition, lithic raw material types were identified for all modified items under the assumption that tools made from nonlocal raw materials would be more likely to be formally shaped or curated. All of these attributes were systematically recorded for all modified items; systematic temporal trends in technology are discussed in the following paragraphs.

Raw Material Use. The geologic formation for modified items made from chert was identified whenever possible. It was expected that different time periods or tool types might exhibit differential use of nonlocal raw materials; either pattern would indicate higher energy expended in procurement or maintenance of these tools. Of the 151 chert modified items, 137 (90.7 percent) were made from locally available chert from the Roubidoux, Gasconade or Jefferson City formations. Five items were made from presumably nonlocal Burlington chert, and these items were distributed among four different strata sets. Three items were made from unidentified high-grade chert, and another six were manufactured from unidentified low-grade chert. This pattern indicates almost exclusive use of locally available lithic raw materials, a pattern which has been replicated in most of the assemblages from tested sites on Fort Leonard Wood (see Ahler et al. 1995).

Technological Industry. Modified items can be manufactured using several different reductive technologies. Both bifaces and unifaces can be manufactured from unmodified blocks of raw

material, from cores that are sequentially reduced and modified, or from large flake blanks that are subsequently modified. These three basic technological industries were identified when possible, with the assumption that the largest amounts of energy would be needed for preparation and manufacture of tools from cores. Manufacture of tools from flake blanks would require less energy, and manufacture of tools from unmodified blocks of raw material would require least energy. In this case, energy expended in tool manufacture is a measure of the energy expended during occupation of the site. Recording these data also permit inference to be drawn regarding overall changes in lithic technological industries through time.

Table 45 shows the distribution of the chipped stone technological industries by strata set. Of the 150 chipped-stone modified items, 84 (56 percent) were manufactured using flake blank technology and 46 (30.7 percent) were manufactured using core reduction technology. All strata sets except Strata Set A, A/B and Feature 2 are dominated by flake reduction technology. Given the specialized nature of the Feature 2 assemblage—formally manufactured and intentionally discarded grave goods—it is not surprising that it is dominated by tools requiring the highest energy for manufacture and maintenance. In addition, though, there is an increase in the proportion of core reduction technology in the upper two strata sets. Core reduction technology was associated with 35 percent of the modified items in Strata Sets A and A/B, but in the lower strata sets only 17.4 percent are assigned to a core reduction technology. This pattern suggests that there may have been a general shift in manufacturing technology during the Late Woodland period. It also suggests that there may have been higher energy investment in the tools that were used and manufactured at Sadie's Cave itself; the shift in technology may not have affected the entire lithic procurement system. It is clear that there was a shift in the Late Woodland period to different reduction technologies that involved more energy expenditure.

Modification Aspect. The modification aspect may be an indirect indicator of the relative intensity of human activity. Longer periods of continuous occupation should result in more energy input into on-site, chipped-stone tool manufacture and use. Cores and ground-stone items were omitted since these modified item classes generally require only minimal energy input. Modified bone was omitted because of the difficulty of comparing energy required for manufacture of bone versus lithic tools and the high incidence of bone tools in Feature 2. Three ranked categories of tool aspect were recognized. Unifacial tool production and use requires the least energy input, and bifacial tools require the most. An intermediate category of bifacial modification on unifacial tool blanks was recognized (biface/uniface), resulting from either intensive utilization or intentional bifacial retouch of unifacial tools.

Table 46 shows the distribution of this attribute by strata sets. As with the technological industry attribute, modification aspect shows a shift toward higher-energy bifacial modification in strata sets A and A/b. Examination of the particular kinds of tools represented reveals that several of the bifacial items in Strata Set A are cached items (see above) or were broken during manufacture. This finding suggests that the types of activities carried out during the Woodland occupations shifted toward more intensive use of bifaces, and that the actual activities performed may have involved caching, replacement or systematical manufacture of bifacial tools. These findings are consistent with other indicators of more intensive or frequent use of the site during the Late Woodland period, and perhaps of more specialized use of the site as well.

Table 45. Distribution of Chipped-Stone Modified Items by Industry and Strata Set.

Strata Set	Core	Flake Blank	Block	Unknown	Total
A	22	35	1	4	62
A/B	3	5		1	9
B	5	27	4	4	40
B/C			1		1
C	5	12		1	19
D			1	1	2
E	1			1	2
F					0
Feature 2	10	5		1	16
Total	**46**	**84**	**7**	**13**	**150**

Haft Modification. Presence of a haft element on modified items is taken as an indication of higher energy input into shaping and continued use of the item. A variety of formal haft element shapes were recognized, including corner-notched, side-notched, lanceolate, straight-stemmed, contracting-stemmed, and expanding-stemmed shapes. In addition, some items showed evidence of modification to facilitate manual prehension (Odell 1985). In many cases, this modification consisted of snapped edges opposite the working edge or intentional backing of some specimens using steep retouch or naturally occurring cortex. Table 47 lists the haft modification in one of four categories—absent, hafted, manual prehension, or unknown. Cores, ground-stone, and bone modified items were excluded from consideration.

Overall, there is little difference among strata with respect to hafting modes. However, the proportion of hafted modified items is highest in strata sets A and A/B, which again reinforces the interpretation that the Late Woodland occupations involved higher energy expenditure in tool manufacturing and maintenance activities.

Reduction Stage. It may be argued that most ground-stone items and all utilized flakes are expedient tools and are not part of any specific reduction trajectory. On the other hand, these artifacts have been intentionally selected from the array of material items available to the Sadie's Cave inhabitants and have been used for tasks that are congruent with the size, shape and physical properties of the tool. Consequently, it is legitimate to include all modified items, even those used in the most expedient fashion, in a reduction stage analysis.

The modified items were assigned to one of four reduction stages based on the degree of modification. Artifacts in the initial stage of modification include tested cores, utilized flakes, rough bifaces, and ground-stone items with only one area of modification. Items with intermediate modification include bifacial blanks and preforms, thick biface fragments, unifaces with modification for backing, hafting or manual prehension, generally reduced cores, and ground-stone artifacts with two or more areas of modification. Finished or fully reduced artifacts include unifaces and ground-stone artifacts with overall shape modification, hafted bifaces, and thin biface fragments. Exhausted artifacts are those that have been so modified by use or shaping that further utilization of the item

Table 46. Modification Aspect for Chipped-Stone Modified Items by Strata Set.

Strata Set	Biface	Biface/Uniface	Uniface	Total
A	31	17	10	59
A/B	5	2	1	8
B	12	9	15	36
B/C			1	1
C	6	1	9	16
D	1		1	2
E	2			2
F				0
Feature 2	13		2	15
Total	**70**	**29**	**39**	**138**

Table 47. Haft Modification by Strata Set.

Strata Set	Hafted	Manual Prehension	Absent	Unknown	Total
A	10	7	30	11	58
A/B 2	1	3	2	8	
B	3	8	18	8	37
B/C			1		1
C	2	1	12	1	16
D			1		1
E	1			1	2
F					0
Feature 2	9		4	2	15
Total	**27**	**17**	**69**	**26**	**139**

was not practical. A few artifacts were recycled into other tool forms and are placed in a separate reduction stage indicative of recycling. However, most of these items were also projectile points that were discarded and recycled by other inhabitants of the cave at a much later time (for example, the Dalton and Graham Cave side-notched points).

Table 48 shows the distribution of reduction stages by strata set. Treating the reduction stages as an ordinal scale of measurement, similar to the debitage reduction stages discussed above, a series of Kolmogorov-Smirnov two-sample tests was used to compare the reduction stage sequences

Table 48. Reduction Stages of Modified Items by Strata Set.

Strata Set	Initial	Intermediate	Late-stage	Finished	Exhausted/Recycled	Total
A	18	25	4	11	5	63
A/B	3	1	2	3	0	9
B	15	15	2	7	2	41
B/C	1	0	0	0	0	1
C	10	5	1	2	2	20
D	1	0	1	0	0	2
E	1	0	0	1	0	3
F	0	0	0	0	0	0
Feature 2	1	7	4	13	1	26
Total	**50**	**53**	**14**	**38**	**10**	**165**

of paired strata. None of the strata pairs produced significant differences, though there is a general trend in the data. Comparing only the major stratigraphic levels and excluding Feature 2 from consideration, modified items in initial stages of reduction generally decrease in proportion through time. The proportions of intermediate-stage and combined late-stage and finished items generally increase through time. Again, this trend points toward increasing energy input int tool manufacture and use during the later occupations of the site.

Tool Curation. The reduction stage, presence of a haft element and evidence of resharpening of one or more edges were all considered in making an assessment of potential or actual tool curation. It was expected that short-term occupation by mobile groups would be marked by high proportions of expedient artifacts. Long-term occupation by groups with low mobility would exhibit a more even mixture of both curated and expedient tools. An occupation that functioned as a specialized activity location in a system of overall low group mobility should exhibit the highest proportion of curated items, reflecting the need for a specialized set of artifacts that are either curated for later use at the same location or are discarded at their location of specialized use after tool breakage or exhaustion. If tools are cached at the site for later use, this should also result in high proportions of unfinished tools that could be completed and used for retooling during later occupations.

To examine these trends, three categories of tool curation were recognized. Expedient tools showed no evidence of resharpening or hafting and were in initial or intermediate stages of reduction. Curated tools showed evidence of formal shaping, hafting, resharpening, or recycling and were also usually in late-stage or later reduction stages. Finally, unfinished tools were those that were in intermediate to late stages of reduction or were broken during manufacture, but showed no evidence of use, resharpening, or recycling. Table 49 shows the number of expedient, curated and unfinished modified items within each strata set.

Table 49. Distribution of Curated Modified Items by Strata Set.

Strata Set	Expedient	Curated/Resharpened	Unfinished	Total
A	25	25	13	63
A/B	4	5	0	9
B	25	12	4	41
B/C	1	0	0	1
C	12	6	2	20
D	1	0	1	2
E	1	2	0	3
F	0	0	0	0
Feature 2	2	17	7	26
Total	**71**	**67**	**27**	**165**

These data indicate that the proportions of curated/resharpened tools increased in the later strata sets, while the proportions of expedient tools generally decreased through time. In addition, there is a marked increase in the proportion of unfinished tools in Strata Set A. Combined with the recovery of several unfinished bifaces in a single cache, these data support the interpretation that inhabitants of the site during Late Woodland times were engaged in caching and retooling activities that are consistent with specialized short-term use of the site. In addition, the high proportion of expedient tools in all of the lower strata sets also support the previous assertion that occupations during this time span were generally of short duration. In addition, general group mobility during these times may have been relatively high.

Summary of Technological Variables

Most of the attributes examined above a consistent picture of increasing energy input into the site activities or occupations that are included in the Late Woodland Strata Set A. The lower strata sets have tool and technological attributes that are consistent with short-term use of the site by small groups of people that are engaged in generally high mobility. These patterns suggest that the site was used either as a short-duration generalized habitation site or as a short-term resource extraction location during most of its occupational history. The type of general settlement system organization (logistically versus residentially organized) in effect during this time span cannot be extracted from these data; the attributes of the modified items are only consistent with short-term use of the site. However, the presence of at least two burials, other pit features and localized concentrations of materials within the site suggest that the site may have functioned as a short-term generalized habitation during most of the pre-Woodland time span.

During the Late Woodland period, use of the site shifted toward more frequent or longer-duration occupations that involved increasing emphasis on production, maintenance, and storage of

curated bifacial tools. This pattern of lithic technological attributes is consistent with use of the site as a specialized, limited-duration field camp or caching/storage facility. This type of site function would only be found in a settlement system that was logistically organized.

Additional examination of the specific functions and used of theses modified items may provide additional support for these tentative interpretations of site function and settlement system organization. This topic is addressed in detail in the next section.

Functional Analysis of Modified Items

Based on the previous analyses of modified items and existing data on the strata, specific expectations can be set forth about modified item diversity. If strata sets B, C, D, and E contain the remains of repeated, but short-term use of the site by a complete residential unit, there should be generally broad diversity of functional classes represented in the modified item assemblages. Alternatively, if these same strata sets contain the remains of short-term specialized occupations by a limited subset of the residential unit, there should be a fairly narrow range of functional classes represented during any given occupation episode. Moreover, if the site was used for the same limited purposes during deposition of a given stratigraphic unit, the associated modified item assemblage for that strata set should be dominated by a very narrow range of functional classes that are directly indicative of the activities performed during these occupation episodes. Finally, if the Strata Set A Woodland occupations contain the remains of more specialized use of the site on a more frequent basis (indicating use of the site as a field camp in a logistically organized settlement system), there artifact assemblage should contain functional classes that are directly related to the main function of the site. Other functional classes may be present as well, because a field camp may be occupied for a few weeks at a time, which would require at least some general domestic maintenance activities as well as the more specialized suite of activities that are related to the specific occupation. Given that the previous analyses indicate that the site never functioned as a generalized domestic base camp or for any long period of duration, none of the strata set assemblages should exhibit a highly diverse and abundant functional assemblage.

It has long been recognized that the functions of lithic tools can be only partially determined from their morphological characteristics (Ahler 1971; Odell 1980; Semenov 1964; Tringham et al. 1974). Up to this point, all discussions of the modified items have been explicitly restricted to descriptive morphological categories and various technological attributes observed through macroscopic inspection of the items. The following analyses of tool functions employ use-wear analysis, with the goals of identifying the modes of kinetic motion in which the tools were used, interpreting the functional diversity of each assemblage, assessing the hardness of objective materials, and identifying specific objective materials for a sample of the modified items.

In recent years, there has been considerable debate between lithic analysts concerning the utility of two competing techniques of use-wear analysis: low-magnification and high-magnification. Low-magnification use-wear was applied to all modified items recovered from Sadie's Cave, except for a few that were recovered from surface or disturbed contexts. In addition, a small sample of 21 items was selected for additional analysis using high-magnification use-wear techniques. Both analyses are discussed in the following sections.

Low-Magnification Analysis

Low-magnification use-wear analysis involves identification of attrition and microflake attributes at magnification levels below about 100x. Attributes are systematically recorded and combined with other observations such as edge angle, evidence of resharpening, location of wear, and overall tool morphology to identify the probable kinetic motions for which the tool was used—cutting, scraping, perforation, etc. This approach has been successfully employed by various analysts (see Ahler 1971; Hayden 1979; Semenov 1964; Tringham et al. 1974). The advantages of low-magnification use-wear analysis are that almost all modified items can be examined and there is a high level of replication of results. In addition, the minor variation in the physical properties of raw materials apparently has little effect on the use-wear signatures used to identify kinetic motions.

The flake scar and attrition attributes used in this study are point, bending and impact flake initiations; feather, step, hinge, and snap flake terminations; and crushing, grinding, rounding, polish, and striation attrition damage. These attributes have been defined by Ahler (1979), and his definitions were followed in this study. Other relevant attributes that contribute to identification of the kinetic motion include the aspect from which use-wear flakes were removed, the plan shape of the modified edge and edge angle (measured by direct observation at 2 mm from the edge, following procedures outlined by Burgess and Kvamme [1978]).

Using these observations, it was possible to define a set of 20 kinetic motions that represent the direction and amount of force applied to the tool edge or surface (Table 50). If more than one edge was present on a single specimen, kinetic motions were determined for each edge. For this reason, the unit of analysis for functional determinations is the modified edge, rather than the item. Analysis at the level of the modified edge provides a more accurate picture of the range and amount of activities performed. This unit of analysis is analogous to Knudsen's (1979) "employable unit." When signatures of more than one kinetic motion were evident on a single utilized edge, all kinetic motion modes were recorded. A total of 224 modified edges was examined, and 271 kinetic motions were identified.

Functional Diversity. Table 51 lists the kinetic motions identified in each strata set. Cutting motion clearly dominates the assemblage as a whole, though scraping, whittling, sawing, raw material reduction, and engraving kinetic motions and unused items are also well represented. In Strata Set C, ten different kinetic motions are represented. Scraping, whittling and cutting motions are almost equally represented, and these three classes account for 64 percent of the 28 kinetic motions identified. Strata Set B is very similar to the Strata Set C assemblage. Again, cutting, whittling and scraping motions dominate the assemblage (67 percent of total), with cutting motions becoming slightly more prevalent (32 percent of total). There is also a slight increase in the number of different kinetic motions identified (s=13). In Strata Set A, cutting motions clearly come to dominate the assemblage, with 44 percent of the kinetic motions placed in this class. Scraping, chiseling and unused items are well-represented, but are clearly in the minority. It appears that there is a trend through time for increasing emphasis on cutting motions in the assemblage of kinetic actions. This trend is most clearly expressed in strata sets A and A/B, where cutting comes to dominate all other kinetic motions.

Table 50. Criteria for Determining Kinetic Motions for Sadie's Cave Modified Items.

Code	Kinetic Motion	Criteria and Significant Attributes
0	Not used	No evidence of use-wear attributes, but item has been visibly modified by shaping
1	Cut	Small flakes with feather termination removed from both dorsal and ventral aspects; low incidence of step or hinge terminations; point initiations; edge angles less than about 40°; rounding and polish often present
2	Whittle	Feather terminations on one aspect only; usually regular flake removals; point initiations, but some bending also; snap terminations at high magnification; edge angles between 30° and 60°; rounding or polish common
3	Scrape	Small to large flakes with step, hinge or snap terminations removed from one aspect only; feather terminations rare; bending initiations; edge angles often more than 60°; rounding or grinding often present; edge cross section may be rounded or faceted
4	Chop	Variable-sized flakes often removed from both aspects; feather, step and hinge terminations; point initiations; crushing and rounding often present; edge angles usually near 60°; edges often sinuous or irregular, occasionally snapped
5	Rotary perforation	Minute feather or hinge terminations on both lateral edges of a generally pointed item; point or impact initiations; edge angle variable, but often in the 60° range; often a single large hinge or snap termination present at the tip; at high magnification, edge use-wear limited to slight rounding
6	Perforation	Very similar to rotary perforation attributes, but little damage or attrition on the lateral edges of the projection; one or more point initiation/hinge termination fractures at distal end of projection; edge angle of projection and lateral margins near 60°
7	Engrave/chisel	Attributes very similar to piercing kinetics; item is always pointed, but most damage is at the very tip rather than lateral edges; use-wear is often rounding and polish; edge angle close to 60°
8	Saw	Similar to attributes for cutting kinetics, but there is also evidence for bidirectional movement parallel to the modified edge; flake scars oriented oblique to the edge, but are not uniform
9	Split	Irregular point or impact initiations on opposing edges of rectanguloid object; hinge or feather terminations; crushing on edges but polish often observed on arrises 2-5 mm from edge; edge cross section is irregular; edge angles between 30° and 60°
10	Gouge	Large and irregular scars with feather and hinge terminations; step terminations absent; similar to attributes of chopping kinetics but flake scars removed from one aspect only; edge cross section often rounded; edge angle close to 60°; use-wear attributes are rounding and polish; some crushing and grinding at high magnification
11	Projectile	Evidence of one or more large impact fractures at distal end of acuminate edge; indicates high-energy piercing and impact with hard material
20	Hammer	Step terminations; impact and point initiations; crushing use-wear dominates at low magnification; edge cross section rounded or faceted

Table 50. Concluded.

Code	Kinetic Motion	Criteria and Significant Attributes
21	Anvil	Similar to hammer motion, but crushing is concentrated in small depressions on the surface of the item; edge angle not determinable; edge cross section is a concave surface; step terminations; point and impact initiations; crushing attrition dominant
22	Grind	Feather or hinge terminations, truncated by grinding and/or rounding; point and bending initiations; edge cross section rounded; edge angle often high; striations common
23	Pigment processing	Traces of hematite observed at any magnification on the surface or edge of modified item; often hematite is embedded in step terminations on the edges of chipped-stone items
30	Raw material	No microscopic evidence of use-wear or micro-flake attrition, but macroscopic evidence of production systematic flake removals for the purpose of raw material reduction and/or flake production
40	Handle	Macroscopic modification of bone item to function as a handle in conjunction with other bone, stone, or wooded modified items; modification involves shaping of the overall surface and/or creation of a socket or other facility for holding other parts of a composite tool
41	Flaker	Crushing evident at distal end of bone/antler modified items; crushing may be at the tip of elongated items or on broader surfaces; evidence of impact with and attrition by very hard materials
99	Unknown	Evidence of use-wear observed but no specific determination of kinetics could be made

In an effort to provide more objective assessment of assemblage diversity, the data in Table 51 were used to calculate diversity index values. Diversity indices, as adapted from ecology, provide a composite measure of both the number of categories in an assemblage and their relative abundance (Brower and Zar 1977). The diversity measure used here is the Simpson Index (Brower and Zar 1977:46; Simpson 1949). The Simpson Diversity index (D_S) is based on probability models, and has the advantages of being a stable indicator of true diversity even with low sample sizes, does not correlate positively with sample size, and can be analyzed using inferential statistics.

Table 52 provides summary data on the functional classes presented in Table 51, including Simpson diversity values for each strata set. Several observations can be made concerning these diversity values. First, the highest diversity value is associated with the tool assemblage from the Feature 2 burial grave goods. This observation indicates that a highly diverse tool kit was in use even in the early periods of site occupation. The lower diversity values in contemporary and later strata are due to differential rates of discard for various curated and expedient tools, not to the fact that the occupants of the shelter were unaware of the range of kinetic motions available to them. Second, Strata Set D produced a high diversity value, even with a low sample size. This finding demonstrates the general lack of correlation between Simpson diversity indices and sample sizes.

Table 51. Distribution of Kinetic Motions by Strata Set at Sadie's Cave.

Strata	Kinetic Motion Code																			
Set	0	1	2	3	4	5	6	7	8	9	10	11	20	21	22	23	30	40	41	99TOTAL
A	10	48	5	14	1	2		9	6	1	1				1		4			6108
A/B		12	1						1			1					1			16
B	4	19	12	9	1	2	1	1	2		1	1					4			360
B/C				1																1
C	2	5	6	7				1		1			2			1	2			128
D	1			1																2
E		2							2			1			1					6
F																				0
Fea. 2	4	6	4	7		2	1	1	7		3		2	2	2	1	1	3	3	150
Total	**21**	**92**	**28**	**39**	**2**	**6**	**2**	**12**	**18**	**2**	**5**	**3**	**4**	**2**	**4**	**2**	**12**	**3**	**3**	**11271**

Table 52. Diversity Indices for Sadie's Cave Functional Classes by Strata Set.

Strata Set	S (No. of Classes)	N (No. of Motions)	D_s value
A	13	108	0.767
A/B	5	16	0.450
B	13	60	0.836
B/C	1	1	0.000
C	10	28	0.870
D	2	2	1.000
E	4	6	0.867
F	0	0	0.000
Feature 2	17	50	0.933

However, sample sizes that are at least as large as the total number of possible classes are recommended when using any diversity index. Third, comparison of the larger assemblages in Strata sets A, B and C shows a consistent decrease in Simpson diversity index values through time.

This finding indicates that the range of activities performed during the Late Woodland occupations was more restricted than in earlier components. Activities associated with Late Woodland occupations focused more strongly on cutting motions. Also increasing in abundance in this strata set are the incidence of chiseling motions, sawing motions and recovery of unused modified items. These trends and observations, when combined with increasing density of artifacts and changes in the ratios of major artifact classes, support the interpretation that the Late Woodland occupations at Sadie's Cave represent specialized short-term use of the site. The site may have functioned as a field camp in the local Late Woodland settlement system, and the higher incidence of curated, but unused items suggests that the site was regularly used.

The relatively high diversity values for strata sets B and C, in combination with moderate numbers of tools and generally low density of artifacts overall in these strata, support the interpretation that the site may have served as a short-term generalized habitation site during the time span associated with these strata (Middle and Late Archaic periods). The remains of several short-term occupations are combined within each of these strata sets, however, and this grouping for analytical purposes may have artificially inflated the composite diversity values for these strata. However, when compared to the values for the lowest strata sets, there is definitely an increase in diversity and density, which lends support for the former interpretation.

The highly variable diversity values, low incidence of tool recovery, and very low density of artifacts in general for strata sets D and E suggest during the Dalton to Early Archaic periods,

the site may have functioned as a short-term resource extraction location in the local settlement system. This finding is consistent with regional settlement system data for this time period.

Hardness of Objective Material. In addition to determination of kinetic motions, low-magnification use-wear analysis was also used to determine hardness of objective materials. This was accomplished by recording the level of magnification needed to clearly observe use-wear attributes. Of particular importance was the magnification level for attrition attributes (crushing, grinding, rounding, and polish). Each modified edge was examined under five different magnification ranges (1x; 1x–10x; 10x–20x; 20x–40x; 40x–80x) using a Unitron 60 stereo-zoom binocular microscope. The level of magnification at which the microflake and attrition attributes became visible was recorded on the standard analysis forms.

From these observations of threshold use-wear visibility, four categories of objective material hardness were recognized—soft, medium, hard, and very hard. Soft materials produce minimal attrition damage on edges and usually result in polish visible only at high magnification levels. Medium hardness is represented by rounding at moderate levels of magnification or polish at low magnification. Hard objective materials produce grinding or crushing signatures at variable magnification levels. Very hard materials almost invariably result in crushed modified edges and surfaces visible at low magnification levels or without magnification. Mixed or indeterminate hardness was also coded, but little information can be extracted form these observations.

Table 53 lists the hardness categories by strata set. These data show little variation through time. All hardness categories are represented in all of the major stratigraphic strata sets (A, B and C), and they are present in generally similar proportions through time. Some exceptions to this uniform distribution can be noted, though. One anomaly is the higher incidence in Strata Set B of edges used on hard objective material (41 percent of the edges). Another shift is apparent in Strata Set A, where there is an increase in the proportion of edges used to modify objective material of medium durability. There is also a slight increase in the proportion of soft objective material and an increase in unused modified edges. The increase in unused edges and items has been noted before, and the increase in soft-medium objective material may be directly correlated with increases in cutting kinetic motions for the same strata set. It appears that Late Woodland occupants of the site were cutting materials of soft and medium durability often enough for this to be seen as a systematic change in the range of activities carried out at the site. However, objective material of all hardness classes are well-represented in Strata Set A, and there is no clear domination of one hardness class over any other. Therefore, the more specialized nature of the Late Woodland occupations had little affect on the range of materials that were being processed or modified at the site.

High-magnification Analyses

In an attempt to provide a better understanding of the range of materials that were being modified during the various occupational periods at Sadie's Cave, a small sample of modified items was selected for more intensive analysis. Twenty-one chipped stone artifacts were examined for traces of use. Eleven artifacts were associated with the Feature 2 burial, while the remaining ten artifacts were taken from various excavation units. The high-magnification method of analysis was employed, which determines tool function based upon patterns of microscopic polishes, striations and edge damage on tool edges (Keeley 1980).

Table 53. Hardness Classes of Objective Material (number of edges) by Strata Set.

Strata Set	Soft	Medium	Hardness Class Hard	Very hard	Unused	Indeterminate	Total
A	23	25	19	7	11	6	91
A/B	6	2	5	1		1	15
B	10	8	21	6	3	3	51
B/C			1				1
C	5	3	5	5	2	4	24
D			1		1		2
E	2		2				4
F							0
Fea. 2	10	2	11	8	2	3	36
Total	**56**	**40**	**65**	**27**	**19**	**17**	**224**

The chipped-stone artifacts included as intentional grave goods in the Feature 2 burial were of particular interest because their intentional placement with a body suggested that this assemblage was viewed as a set of functionally related items by those who interred the body and the grave goods. In addition, the set of grave goods may also be directly associated with the role and economic activities engaged in by either the specific person buried in the grave or by all people who were of similar economic or social standing. In this case, the burial was that of a young female, and all of the grave goods were formal tools that could be associated with some type of domestic processing or manufacturing activities (grinding, scraping, basketry [?], resharpening or reshaping tools, etc.). No projectile points or weaponry of any kind was found, but flintknapping tools were included in the assemblage (antler tine flakers and a billet). It was of particular interest to determine more specific functions for these tools. Figures 33 through 35 depict the eleven chipped-stone tools from the Feature 2 burial.

The remaining ten artifacts were selected for more intensive examination because they either displayed particularly noticeable polish or were of other analytical interest (possible hafted tools, retouched unifaces, etc.). Figures 52 and 53 show the tools that were selected for analysis from general excavation contexts. Table 54 provides data on the context and use-wear attributes of all tools examined for traces of high-magnification use-wear.

Methods. The analysis was performed with a binocular, incident-light microscope with magnifications of 30x to 400x. Artifacts were cleaned in an ammonia-based detergent prior to analysis. Preliminary inspection of the tools indicated that additional cleaning in dilute HCl and NaOH to remove organic and inorganic material adhering to tool edges was unnecessary.

A comparative collection of 100 experimental stone tools was used to interpret the archeological use-wear patterns. These tools were use by the author to perform a variety of tasks

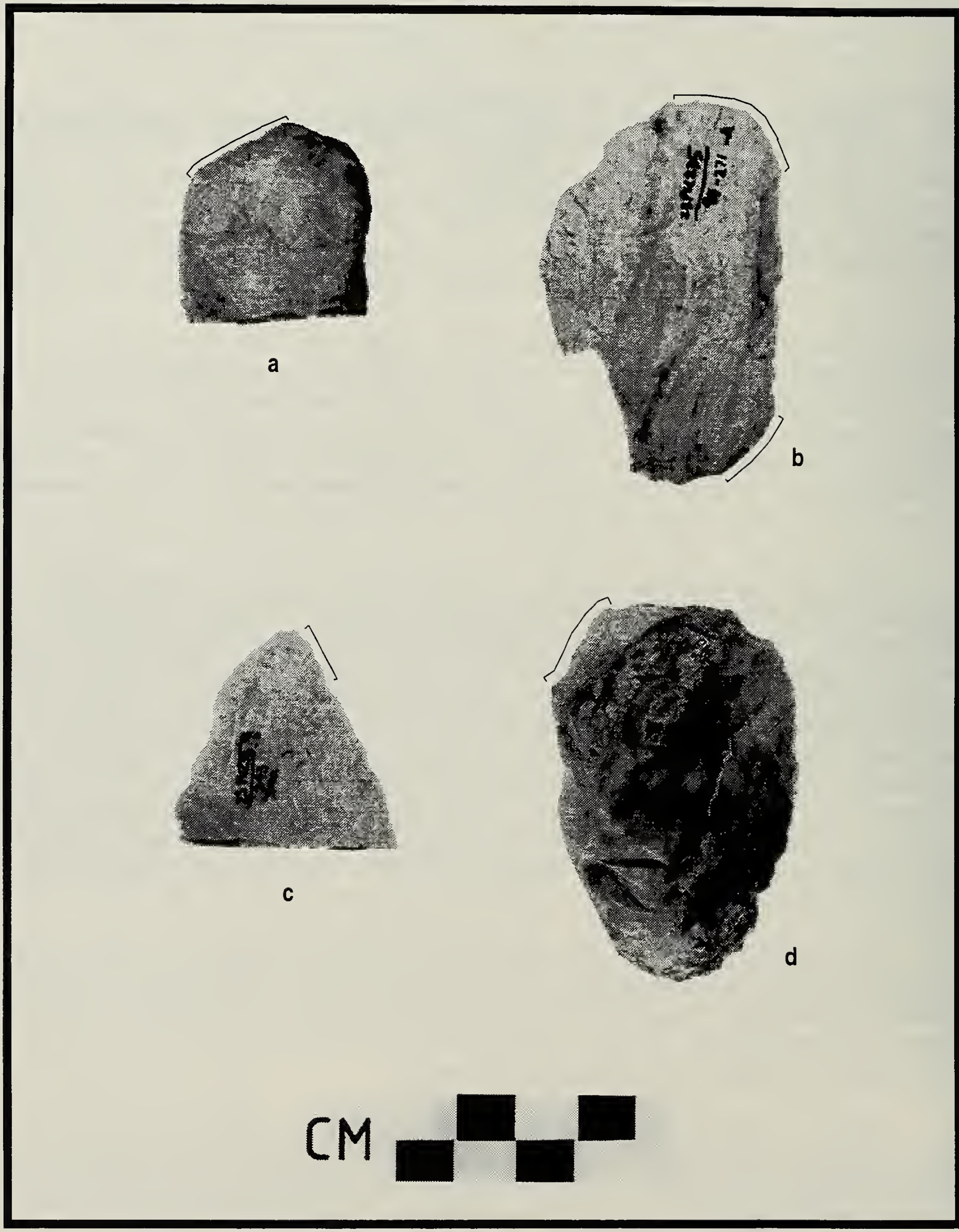


Figure 52. Modified Items Selected for High-magnification Use-Wear Analysis: a, thin biface/scraper; b, thick biface/scraper; c, thin biface/scraper; d, hafted unifacial scraper (Brackets show locations of use-wear polish traces).

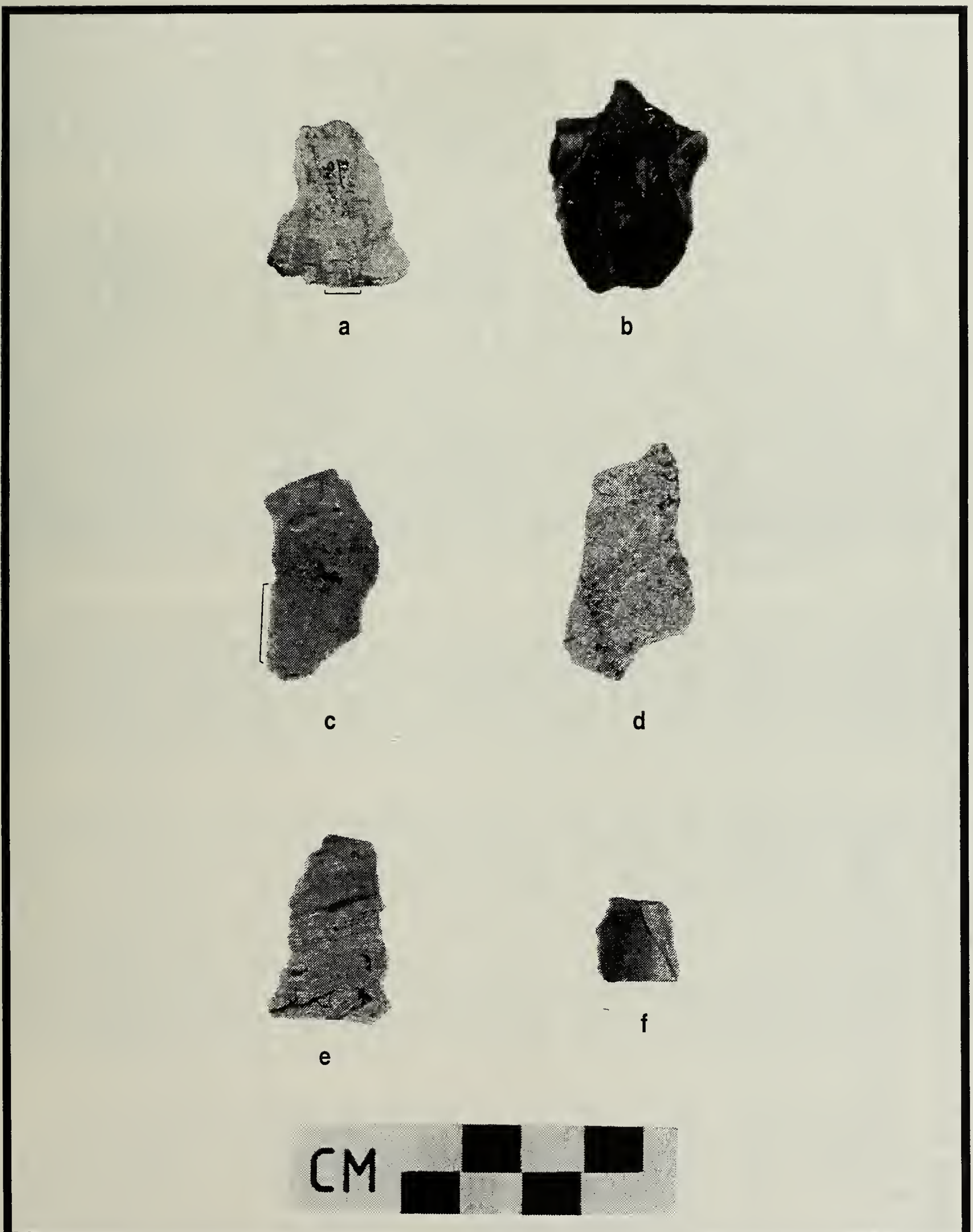


Figure 53. Modified Items Selected for High-magnification Use-Wear Analysis: a, haft element/wood hafting traces; b, haft element/not used; c, utilized flake/wood whittling tool; d, backed knife/post-depositional soil polish; e, utilized flake/post-depositional damage; f, utilized flake excavation damage (Brackets show locations of use-wear polish traces).

Table 54. Contexts and Functional Attributes of Modified Items Examined for Use-Wear by High-magnification Techniques.

Item Number	Figure Numbers	Provenience	Strata Set	Morphological Category	Low-magnification Function	Hardness	High-magnification Function
116-B	29, 33a	TU2/F2	C (Feature 2)	Hafted biface	Gouge at distal end; unused lateral margins	Soft	Dry hide scraping
116-C	29, 33b	TU2/F2	C (Feature 2)	Thin biface	Sawing/cutting; recently resharpened	Hard ?	No use-wear traces observed
116-I	29, 33c	TU2/F2	C (Feature 2)	Thick biface	Not used	N/A	No use-wear traces observed
116-G	29, 33d	TU2/F2	C (Feature 2)	Thick biface	Edge grinding from manufacture	N/A Very hard	Edge grinding only; no use-wear traces observed
116-D	29, 34a, 54a	TU2/F2	C (Feature 2)	Bifacial hafted end scraper	Scraping/gouging	Soft	Dry hide scraping overlaying silica (digging) polish
116-E	29, 34b, 55a	TU2/F2	C (Feature 2)	Bifacial hafted end scraper	Scraping	Soft-medium	Fresh hide scraping
116-H	29, 34c, 55b	TU2/F2	C (Feature 2)	Bifacial hafted end scraper	Scraping/gouging	Soft, little use evident	Wood scraping
116-O	29, 34d	TU2/F2	C (Feature 2)	Bifacial hafted end scraper	Scraping	Medium	Dry hide scraping; wooden haft traces
116-A	29, 35a, 54b	TU2/F2	C (Feature 2)	Utilized flake	Whittling/scraping	Soft/medium	Dry hide scraping
116-P	29, 35b	TU2/F2	C (Feature 2)	Bifacial hafted perforator	Rotary perforation; recently resharpened	Hard ?, little use evident	No use-wear traces on tip; grinding on haft element
116-T	29, 35c	TU2/F2	C (Feature 2)	Thin biface	Indeterminate; little use use observed	Unknown	Splitting wedge used on bone or wood
219-2	52a	TU5/S3-5 (L9)	B	Thin biface	Scraping/cutting	Hard	Dry hide scraping
271-A	52b	TU7/L2	A/B	Thick biface	Cutting; partial resharpening of edges	Soft	Dry hide scraping
243-1	52c	TU6/S1 (L3)	A	Thin biface	Cutting/scraping; partial resharpening of edges	Soft	Dry hide scraping
237-7	52d	TU6/S1 (L2)	A	Unifacial hafted end scraper	Scraping	Medium to hard	Fresh hide scraping and hammerstone traces
247-A	53a	TU7/S1 (L1)	A	PPK haft; recycled into burin	Chiseling	Hard	Wood traces at haft
226-5	53b	TU6/S1 (L1)	A	PPK haft only	Not used; hafting only	Hard; not used	No use-wear traces observed
226-3	53c	TU6/S1 (L1)	A	Utilized flake	Cutting/whittling	Medium/soft	Wood whittling
298-1	53d	TU6/S3 L(9)	C	Backed knife	Whittling/scraping	Medium/mixed	Post-deposition soil polish
134-1	53e	TU4/S3-5 (L6)	B	Utilized flake	Cutting/scraping/ whittling	Medium/mixed	Post-deposition damage only; no use-wear traces observed
266-1	53f	TU6/S2 (L5)	B	Utilized flake	Chopping (?); polish at surface only	Soft	Excavation damage; metal or glass contact

on various types of raw materials. Experiments were designed to replicate as closely as possible activities which may have been performed aboriginally. Activities performed included scraping, cutting, piercing, boring, and sawing. The comparative collection of experimental tools includes observations of use-wear traces left after experimental cutting and scraping of antler, bone, turtle shell and mussel shell (n=32), wood (n=30), fresh and dry hide (n=14), cattail and domestic grasses (n=11), squash/gourd (n=3), meat (n=4), and soil and stone abrasion (n=6).

Analysis of Feature 2 Artifacts. Eleven of the analyzed artifacts were recovered from a human burial context (116-A,B,C,D,E,G,H,I,O,P,T). As Table 53 indicates, the most common wear traces observed are those produced by dry-hide scraping. This category is followed by one example each of fresh-hide, wood, and silica or "hoe" polish.

One large biface (116-D) exhibited both dry-hide traces and a bright, smooth polish similar to "sickle sheen" or "hoe gloss". This polish was observed as isolated patches on the ventral face of the tool and appears to have been nearly completely removed by later flaking and use of the tool. The right side of the distal edge shown in Figure 34a exhibits dry hide polish, which has formed over the glossy polish. This tool appears to have been a curated implement which functioned first as a digging implement and was later converted into a hide scraper. Figure 54a shows the roughly pitted dry hide polish at the tool edge overlapping smoother and brighter silica polish away from the edge.

Although the presence of hafting elements on several of the artifacts clearly indicates that some of the tools were hafted, only one piece (116-O; Figure 34d) revealed traces on the surface and margins of the haft element that indicate it was secured in a wooden haft. It is likely that most of the tools were hafted tightly; hafting polish would develop only when the tool was loose and rubbing against the haft. This item also showed traces of dry hide polish over most of the distal margin shown in Figure 34d.

Artifact 116-T, a thin biface fragment, exhibited intensive crushing at the distal end shown in Figure 35c, and several microscopic step scars were observed on the margin opposite this crushing. This pattern of damage resembles that produced by splitting or wedging. Only isolated bright spots of polish were observed on this piece near the crushing and microscarring. This suggests that a hard material was worked, possibly wood, but more likely an osseous material. The latter is harder than wood and tends to produce polishes at a slower rate and mainly as isolated spots. Wedging/splitting experiments indicate that using a hard hammerstone produces bright, smooth polish streaks at the point of contact. Such streaks were not observed on this piece, suggesting that a wood or osseous baton was used as a hammer.

Two pieces exhibited traces analogous to those produced by edge grinding with stone. One of these (116-G; Figure 33d) is a biface. The grinding on this piece may reflect edge preparation during bifacial flaking. The other artifact is a bifacial drill (116-P; Figure 35b). The grinding on this piece is on the proximal end, and is most likely related to hafting or prehension. No traces were observed on the "bit" of this piece, though the edges here appeared freshly flaked. This may indicate that the tool was rejuvenated immediately prior to burial, or that it was used to work relatively hard material which removed wear traces as they were formed. No rounding or pitted polish, suggesting hide working, was observed on this piece.

The single nonformal tool included in the Feature 2 assemblage is a large utilized bifacial thinning flake (Figure 35a). This item showed traces of dry hide polish on the ventral aspect of the right distal margin, as shown in Figure 35a. Though this item showed no traces of hafting modification or other formal shaping, the utilized edge was considerably rounded, indicating a high intensity of use. Figure 54b shows the rough polished surface associated with working dry hide. High-magnification analysis indicated the use mode for this tool as dry hide scraping, while the low-magnification results indicated a combination of cutting and scraping of soft to medium materials. These differences in interpretation may be due to the high intensity of tool use; more intensive use on soft materials may be misinterpreted as use on increasingly harder materials due to greater edge-wear attrition.

One artifact (116-E; Figure 34b) revealed traces on the ventral face in the center of the distal margin that were attributed to working fresh hide. The polish produced by fresh hide is less glossy and more grainy than that produced by working dry hide. Figure 55a shows the fresh hide polish from Item 116-E at the same magnification as the dry hide polish shown in Figure 54b.

Finally, one item (116-H; Figure 34c) had traces of polish on the dorsal aspect of its right distal margin that were indicate use of the tool on wood. This type of polish (Figure 55b) is similar in brightness to silica polish (see Figure 55a), but is more irregular in its distribution and exhibits deeper and larger pits.

The modified items from the Feature 2 grave good assemblage show a variety of polishes, but the use-wear is clearly dominated by traces of dry hide. Most of the inferred kinetic motions involved scraping, though whittling is also present in at least one example. In general, there is good agreement between the kinetic motions defined using low-magnification analysis and the functions identified using high-magnification analytical techniques. However, there are some systematic differences that emerge when comparing the results of the two techniques.

One difference relates to the degree of utilization or intensity of use of a tool. Under low magnification, increasing tool use is seen as increased attrition and edge damage that may be interpreted as evidence of use on successively harder objective materials. This misinterpretation does not occur when using high-magnification analysis. The polishes that are characteristic of working specific materials do not change their appearance, regardless of the intensity of tool use. However, if the same item is used to work a variety of objective materials, it would be difficult to segregate the polishes. This situation might result in identification of only the last use episode, or might present a mixture of polishes that are ambiguous and uninterpretable. Potential misidentification of the hardness of the objective material occurred with Item 116-A and with other artifacts from general excavation levels.

Analysis of Artifacts from Excavation Levels. In addition to the artifacts from the burial context, ten artifacts from different units and stratigraphic levels were analyzed (Table 53). This sample was selected nonrandomly by the primary author to include a variety of tools that exhibited strong evidence of use-wear or polish. The sample included five unifacial and three unhafted bifacial artifacts. Two haft elements of projectile point/knife artifacts were included for analysis to determine if the hafting material had left traces on the tool. One of these (Item 247-A) also showed evidence

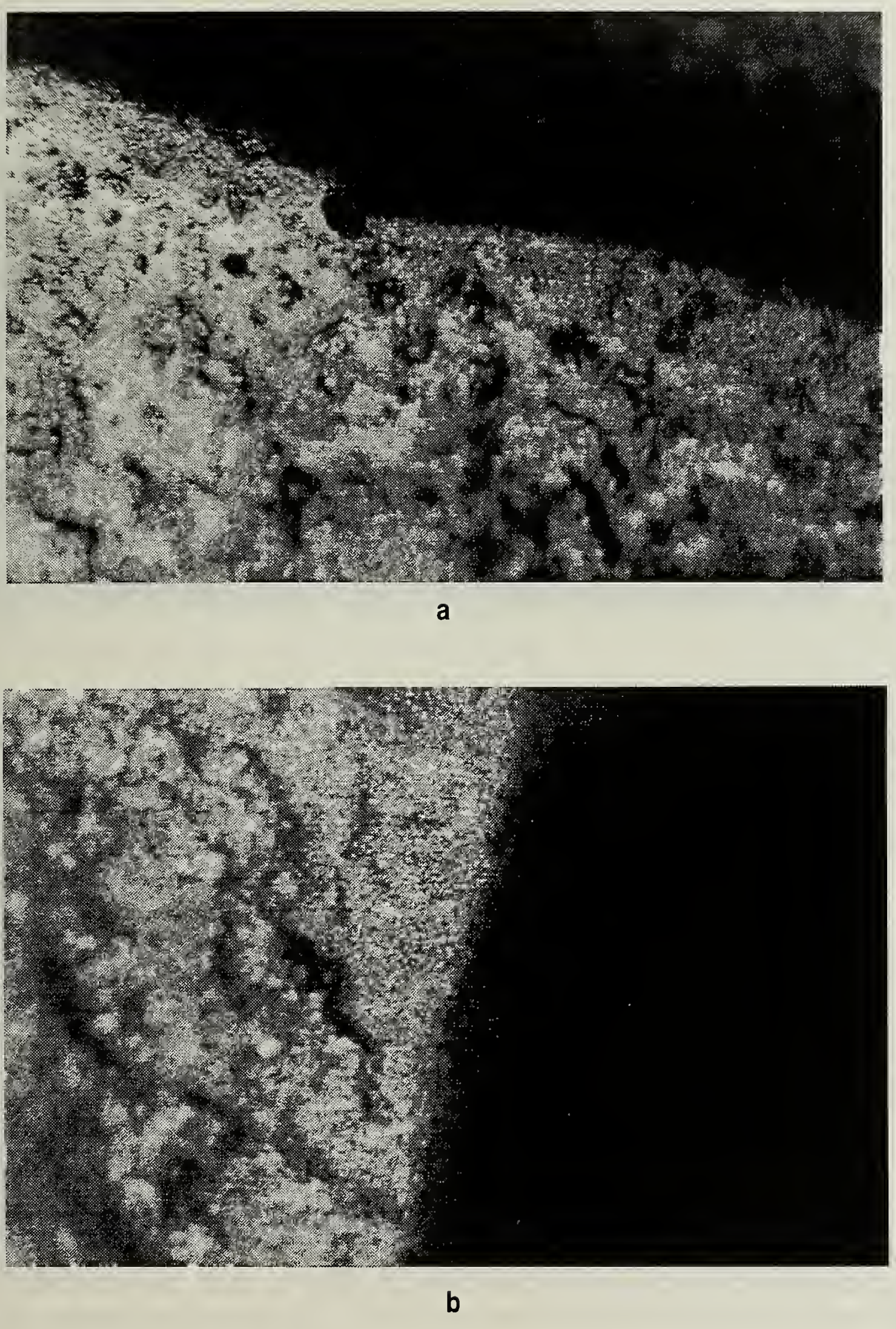
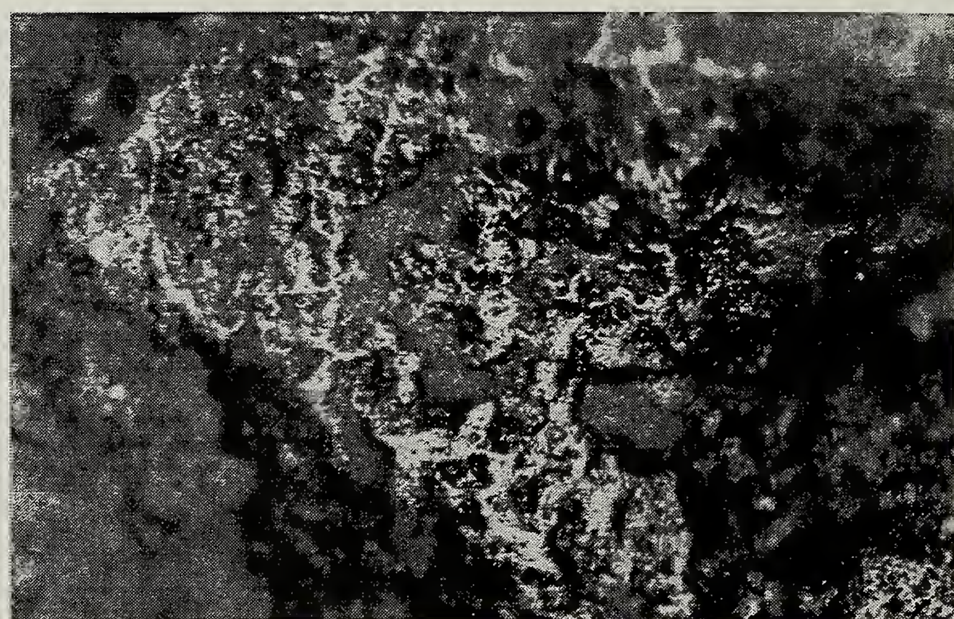


Figure 54. Photomicrographs of Representative Microwear Polishes: a, Item 116-D at 160x magnification showing dull dry hide polish at tool edge overlapping bright silica polish away from edge; b, Item 116-A at 160x magnification showing dry hide polish.

a



b

Figure 55. Photomicrographs of Representative Microwear Polishes: a, Item 116-E at 160x magnification showing faintly pitted fresh hide polish; b, Item 116-H at 160x magnification showing bright, irregular and deeply pitted wood polish.

at low magnification of rejuvenation and reuse as a burin or engraving tool. The general results of the analyses are shown in Table 53.

The most common traces present on these pieces can be attributed to postdepositional processes, such as soil abrasion and excavation damage. Postdepositional damage is present on Items 298-1, 134-1 and 266-1, all of which were interpreted as unifacially modified items. Item 298-1 had been documented through low-magnification analysis as a backed knife that had been used for whittling and scraping materials of medium hardness. Postdepositional damage resulting from artifact redeposition or surface erosion may have obscured all surface traces of use-related polish. The overall morphological attributes and macroscopic edge damage on indicate that it was an intentionally modified item, but no specific use-wear polished were identifiable. Item 134-1 is a utilized flake that had overall edge damage that was interpreted as evidence for multiple uses (cutting, scraping and whittling) under low magnification. This item also produced no use-wear polishes. It may have been subjected to postdepositional trampling as well as the uncontrolled heating observed by both analysts. The combination of the effects of heating and other damage may have created false positive indicators of macroscopic use-wear. Item 266-1 is a utilized flake with polish on the surface of the item, not at the edge. This item was examined at up to 80x magnification during the low-power analysis, and no traces of metal or other excavation-related damage were observed. It was interpreted as a possible fragment of a larger chopping tool that had been polished away from the edge, but there was still doubt about the validity of this identification. High-magnification analysis demonstrated that the surface polish derived from contact with metal or glass, probably during excavation or laboratory processing.

Three pieces (Items 247-A, 226-5, and 134-1) exhibited a sheen which is most likely due to intentional or accidental burning of the artifacts. These include the two projectile point haft elements and one of the utilized flakes. This surface alteration due to burning may have obscured most traces of use-related polish. However, Item 247-A still retained traces of probable haft-related wood polish at its basal margin (see Figure 53a). The other haft element showed no traces of use-related damage in either analysis, but lateral haft element grinding was observed by both analysts.

Use-wear traces which appear to represent actual prehistoric utilization are dominated by dry-hide scraping. Three artifacts (Items 219-2, 271-A, and 243-1) exhibited this polish type, and all were interpreted as scraping tools. The low-magnification analysis of these same tools identified scraping and cutting motions in two instances (Items 219-2 and 243-1) and cutting motion in the other case. Soft material was correctly identified as the objective material for two of these artifacts (271-A and 243-1). Heavy use of Item 219-2 may have caused the objective material to be classed as hard by the low-magnification analyst.

One piece (Item 226-3) appears to have been used to whittle wood. This item was identified as a cutting/whittling tool under low magnification. The remaining artifact (Item 237-7) exhibited traces of fresh hide working. It was identified by both analysts as a scraping implement, but again, high intensity of tool use may have contributed to the identification of the worked material as hard material in the low-magnification analysis.

Summary of High-magnification Analyses. The high-magnification use-wear analyses of selected modified items from Sadie's Cave have produced some informative patterns. This summary recognizes that the analyzed sample of tools drawn from general excavation levels is small and

nonrandom, and therefore cannot be thought of as representative of the assemblages as a whole. Still, some tentative patterns have emerged that bear discussion.

First, six of the ten modified items from excavation levels were associated with Strata Set A. Three of these items were identified through high-magnification analysis as implements employed in dry-hide scraping. No cutting motions were noted. These results differ somewhat from the results of the low-magnification use-wear, which identified all three of these bifacial tools as either cutting tools or combination cutting and scraping tools. This difference in interpretation of motions is probably related mainly to heavier reliance on the overall morphological shape, edge angle and modification aspect (bifacial) of the item in the low-magnification analysis for identification of kinetic motions. It has been demonstrated through experimental and archaeological analyses that tool form and tool function are not necessarily correlated (Ahler 1971; Hayden 1979; Semenov 1964). However, overall morphology and shape still play important roles in the functional classification and interpretation of artifacts. Short of reverting to a completely descriptive, and less informative, typology, there is no way to avoid introducing functional interpretations into the morphological categories.

The lack of confirmation of cutting kinetic motions in the sample of artifacts from Strata Set A raises some concern, because the low-magnification use-wear analysis indicated that cutting tools dominated the Strata Set A assemblage. If cutting motions cannot be confirmed through high-magnification analysis, this throws into question the general interpretations of the temporal trends in site function. Two additional factors must be raised that may restore confidence in the low-magnification results. First, all of the unconfirmed motions were observed on bifacial tools, which are notoriously difficult to assess using high-magnification analysis (see Keeley 1980). The polish observed on these curated and often resharpened tools represent on the latest episode of tool use in what may have been a long and multifaceted career. Second, no unifacial cutting tools from Strata Set A were examined in the high-magnification analysis, though they make up a large proportion of the tool assemblage. This is a result that stems directly from the nonrandom and nonrepresentative selection of tools for extended examination. If the entire Strata Set A assemblage were examined under high-magnification, these results would undoubtedly change. Considering all of these factors, it is reasonable to retain the low-magnification results and to consider that the high-magnification data acts to refine and enhance the generalized trends that are derived from low-magnification analysis.

When the results of the analysis are compared for the Feature 2 grave goods, replicability increases. In part, this is due to the strong correspondence between morphology and function for scraping tools, which represent the majority of the assemblage. It is also encouraging that nonuse of tools was independently identified by both analysts in several cases. These findings permit interpretation of the Feature 2 grave goods with a higher degree of confidence. It appears that this special-context assemblage may very well represent the array of tools that were seen as appropriate, useful, and necessary for continued survival in the afterlife. The person buried in Feature 2 was sent onward well-equipped with both tools (scrapers, drill, mano, splitting wedge), unfinished tool blanks, and the means for maintaining these tools as functional objects (handles; flakers and billet for resharpening chipped-stone items).

Summary of Functional Analyses

The results of the high- and low- magnification use-wear analyses were not completely mutually reinforcing. This is not surprising, however, since these analytical methods have different goals and are designed to produce different interpretations of modified stone tools. It is our recommendation that if possible, a combination of both analytical techniques be applied when attempting to address functional analysis of stone-tool assemblages. Combined analyses can utilize the best of both methods. All (or a very high proportion) of the tools can be examined under low magnification, which will provide data on assemblage diversity. More labor-intensive, high-magnification analysis should be applied to a selected subset of the assemblage. This step-wise analysis can provide independent tests of general trends and diversity data, and should also provide more detailed interpretation of at least some of the artifacts in the assemblage.

For the Sadie's Cave assemblages, functional analyses of the modified items suggest a shift in use of the site from a generalized, short-term residential camp during the Middle and Late Archaic periods toward a more intensive, but increasingly specialized use of the site as a field camp during the Woodland period occupations. There is consistent evidence for increasing energy input into modified item production and maintenance during the occupation of Strata Set A, and evidence from low-magnification use-wear analysis suggests that the activities performed became more intensively focused on cutting motions. The incidence of unused, but modified and partially reduced, tools also increases during this occupational period.

These findings suggest that the site may have functioned as a specialized field camp in a local, logistically organized Late Woodland settlement system. Activities may have focused on processing collected plant remains or, as suggested by the high nonrandom sample of artifacts examined by high magnification, processing both fresh and dry hides. Tools that may have been used for these activities were stored at the site in partially reduced stages of manufacture, which reinforces the interpretation of repeated use of the site for a similar range of activities.

Analysis of Human Skeletal Remains

The analysis of Skeleton 1 (Feature 2) from Sadie's Cave relied predominately upon the procedures suggested by Buikstra and Ubelaker (1994) in *Standards for Data Collection from Human Skeletal Remains*. The age of this individual was estimated by evaluating pubic morphology (Brooks and Suchey 1990; Gilbert and McKern 1973; Meindl et al. 1985; Todd 1921), dental development (Moorees et al. 1963; Thoma and Goldman 1960; Ubelaker 1978), and epiphyseal closure (Brothwell 1972; MacKay n.d.; Ubelaker 1978; Webb and Suchey 1985). The sex was determined by comparing cranial and innominate morphology to the series of illustrations provided by Buikstra and Ubelaker (1994:15-21) which represent the female, possible female, unknown, possible male, and male features for each skeletal criterion. These illustrations were developed in an attempt to provide some standard comparison of criteria among different researchers. Particular features used were the nuchal crest, mastoid process, glabella, and supraorbital margin on the cranium, the mental eminence of the mandible, and the greater sciatic notch on the innominate. Measurements were taken of the dentition, cranium and complete long bones when possible. Measurements were taken using a sliding caliper, an osteometric board, and a metric cloth tape. Since rates of attrition can be used to evaluate both diet and age of an individual, the degree of dental wear was also recorded following

Murphy (1959) and Scott (1979). Additional information was gathered on the presence or absence of nonmetric traits, and all elements were observed macroscopically for pathological conditions.

Skeleton 1 is an adult female, approximately 17-18 years of age. The presence of shovel-shaped incisors indicates that the individual was a Native American. The elements that were present were very well-preserved, albeit frequently incomplete. Only two long bones (the right radius and ulna) were complete enough to use in estimating stature. An inventory of elements present is provided in Table 55.

Stature estimates using the radius and ulna suggest that this individual was between 159.09 and 168.02 centimeters in height (using the formula for Mongoloid). The range is large since these particular long bones tend to vary more in proportion to height than other elements such as the femur. Nonmetric traits were represented by the presence of a supraorbital notch that was complete on the left supraorbital margin and partially enclosed on the right side. In addition, both humeri exhibited a septal aperture on the distal end of the diaphysis. An enamel pearl was also present on the mesial root of the mandibular third molar (right). A summary of dental and post-cranial measurements is provided in the accompanying tables (56 and 57).

Several pathological conditions were observed. Both femora had signs of active periostitis upon the lateral surfaces of the diaphysis, covering less than 10 percent of the total bone surface. No signs of healing were present, suggesting that this condition was still active at the time of death. The etiology of this general infection cannot be ascertained at this time since there was no additional evidence of a specific condition (e.g., trauma) that could account for the infection. A small lesion (1.3-x-0.32 cm) was also present on the inferior surface of the medial diaphysis of the right clavicle. The edges of the lesion appeared to be smooth, suggesting that possibly some healing was occurring at the time of death. This lesion may or may not have been related to the condition suggested by the periostitis. An additional small smooth-walled lesion was also present on the proximal surface of the third right metatarsal of the foot. A small, smooth-walled indentation was located on the interior surface of the right parietal adjacent to the sagittal suture. There is no evidence of any bone reaction (proliferative or resorptive) in the vicinity of this anomaly that would suggest a pathological origin. Rather, this indentation is probably a developmental anomaly.

The cause of death is unknown. Although there are signs of infectious disease, the extent to which this individual's death was affected by the condition cannot be ascertained.

In addition to the skeleton recovered from Feature 2, additional human bone was recovered during the course of the excavations. Table 58 provides a general inventory of these skeletal elements. Several disarticulated elements were recovered from Test Units 2 and 6 in levels adjacent to the Feature 2 burial; these elements, though not articulated or recovered from the grave itself, have been assigned to Feature 2. The bones assigned to Feature 3 represent another known intentional burial at the site, but this individual was not excavated and was only partially exposed in the floor of Test Unit 4. The bones removed from this burial during exposure were identified in the field using Bass (1971) as a reference guide, and were reburied with the unexcavated remainder of the burial. In addition to the bones that can be definitively assigned to Feature 3, the disarticulated elements from Test Unit 4, Levels 4–6 also may be associated with that burial. At least one

Table 55. Inventory of Human Remains from Feature 2 (Nondental).

Element		Left	Right	Element		Left	Right
Frontal	+			Scapula		+	+
Parietal		+	+	Clavicle		–	+
Occipital	+			Manubrium	–		
Temporal		+	+	Sternal Body	–		
TMJ		+	+	Humerus		+	+
Zygomatic		+	+	Radius		+	+
Palatine		+	+	Ulna		+	+
Maxilla		+	+	Ilium		+	+
Nasal		+	+	Ischium		+	+
Ethmoid	+			Pubis		+	+
Lacrimal		+	–	Patella		+	+
Vomer		–	–	Femur		+	+
Sphenoid	+			Tibia		+	+
Inf. Nasal Concha		+	+	Fibula		+	+
Stapes		–	–	Navicular		–	+
Malleus		–	–	Lunate		+	–
Inca		–	–	Triquetral		+	–
Hyoid	–			Pisiform		–	–
Mandible	+			Grtr. Multangular		–	–
				Lssr. Multangular		+	–
1st rib		–	–	Capitate		–	+
2nd rib		–	–	Hamate		–	+
3–12 (# present)		5		Metacarpal 1		+	+
				Metacarpal 2		+	+
Cervicle vertebrae	4			Metacarpal 3		–	+
Thoracic vertebrae	3			Metacarpal 4		–	–
Lumbar vertebrae	4			Metacarpal 5		+	–
Sacral element	5			Talus		+	+
				Calcaneus		+	+
Hand Phalanges				Cuboid		–	+
Proximal	5			Navicular		–	+
Medial	1			Cuneiform 1		–	–
Distal	4			Cuneiform 2		–	–
				Cuneiform 3		–	–
Foot Phalanges				Metatarsal 1		–	+
Proximal	4			Metatarsal 2		–	+
Medial	0			Metatarsal 3		–	+
Distal	0			Metatarsal 4		–	+
				Metatarsal 5		–	+

Note: + and – indicate presence or absence of an element. Numerals indicate the number of vertebral or phalangeal elements present.

Table 56. Inventory of Dental Remains from Feature 2.

Tooth	Condition	Attrition Murphy (1959)	Attrition Scott (1979)	Mesio-distal	Labio-lingual	Crown Height
Right Maxilla						
M3	2	0	4	0.99	1.11	0.71
M2	2	0	12	0.95*	1.11	0.69
M1	2	d2	23	0.99*	1.10	0.62
P2	2	b1	—	0.61*	0.98	0.69
P1	2	b1	—	0.64*	0.99	0.72
C	2	a	—	0.80*	0.82	0.92
I2	3	—	—	—	—	—
I1	2	b1	—	0.77*	0.74	0.88
Left Maxilla						
I1	2	b	—	0.79*	0.72	0.82
I2	2	b1	—	0.71	0.67	0.75
C	2	a	—	0.78	0.81	0.87
P1	2	b1	—	0.62*	1.02	0.75
P2	2	b1	—	0.60*	0.95	0.63
M1	2	d2	23	1.01*	1.10	0.53
M2	2	0	12	1.00	1.10	0.71
M3	2	0	4	1.02	1.09	0.71
Right Mandible						
M3	1?	0	0	1.19	1.10	0.83
M2	2	a	12	1.05*	1.00	0.60
M1	2	d	23	1.00*	1.09	0.50
P2	3	—	—	—	—	—
P1	3	—	—	—	—	—
C	2	a	—	0.69	0.72	0.91
I2	2	a	—	0.55*	0.60	0.70
I1	2	b	—	0.46	0.53	0.58
Left Mandible						
I1	2	b	—	0.50	0.53	0.61
I2	2	b	—	0.60*	0.60	0.68
C	2	a	—	0.69*	0.69	0.90
P1	2	a	—	0.70	0.75	0.66
P2	2	a	—	0.73	0.81	0.59
M1	2	d	24	0.96*	1.00	0.50
M2	2	0	11	1.05	1.10	0.58
M3	3	—	—	—	—	—

Note: 1=present, erupting; 2=present, development complete; 3=missing, post-mortem. All measurements are in cm. An * indicates that some interproximal wear is present, resulting in biased measurements.

Table 57. Measurements of Skeletal Elements from Feature 2.

Element/Measurement	Left	Right	Element/Measurement	Left	Right
Humerus/Biepicondylar Breadth	4.00	4.10	Tibia/Nut. Foram Diameter, D-V	1.88	1.82
Ulna/Maximum Length		24.8*	Tibia/Nut. Foram Diameter, M-L	0.78	0.79
Ulna/Shaft Diam. D-V (Min)		1.20	Tibia/Prox. Bicondylar Breadth		5.25
Ulna/Shaft Diam. D-V (Max)		1.20	Tibia/Dist. Epicon Diam, D-V	1.38	
Ulna/Least Circum. (Dist.)		2.70	Tibia/Dist. Epicon Diam, M-L		2.10
Radius/Maximum Length		23.0*	Tibia/Circ. at Nut For	7.80	7.40
Radius/Shaft Dia, D-V (Min.)		0.90	Fibula/Dist. Least Circumference		2.90
Radius/Shaft Dia, M-L (Max.)		1.22	Calcaneus/Maximum Length	5.27	
Radius/Head Diameter (Max.)	0.85	0.92	Calcaneus/Min Body Breadth	1.00	
Scapula/Glenoid Height	2.32	2.35	Calcaneus/Body Height	3.18	
Scapula/Glenoid Breadth	1.21	1.30	Calcaneus/Middle Breadth	2.25	
Femur/Subtroch Dia, D-V	0.90	1.00	Talus/Maximum Length	3.42	
Femur/Subtroch Dia, M-L	1.80	1.80	Talus/Maximum Breadth	2.35	
Femur/Head Max. Dia.	2.95		Talus/Maximum Height	1.99	
Femur/Neck Dia, Vert	1.55		Cranial/Mastoid Length	2.41	
Femur/Neck Dia, Trans.	1.12		Cranial/Interorbital Breadth	1.31	

* This element was reconstructed, resulting in a slightly biased estimate.

rodent burrow was noted in the field that had disrupted the central portion of Feature 3. Other individuals that are represented in the Sadie's Cave assemblage include elements representing a young child recovered from Test Unit 6/Level 8 and another young child in Test Unit 5. The elements from Test Unit 5/levels 7-8 could easily have been transported from the nearby Feature 3, but the three elements from Test Unit 5 levels 10-12 may well represent a separate individual. Test Unit 7 produced a single cranial element from Stratum 3 that represents another individual. Finally, Test Unit 3 produced a single mandibular incisor; this element may be part of a burial or it may represent attrition due to disease or decay.

While the remains of at least five individuals are represented in the Sadie's Cave human skeletal assemblage, these remains are not associated with the same analytical unit or strata set. Feature 2 and an unexcavated young child are associated with Strata Set C, Strata Set B contains the remains of the Feature 3 individual, an unprovenienced young child, and another adult from Test Unit 7/Stratum 3. Another adult may be associated with either Strata Set B or C in Test Unit 5 (bones from levels 10-12). In spite of the overall high frequency of human remains in the cave, the site is not interpreted to have functioned as a specialized mortuary facility at any time during its occupational history. It should be remembered that each strata set represents between 1,400 and

Table 58. Other Human Skeletal Material from Sadie's Cave.

Bag No.	Unit No.	Level	Element	Comments
101	2	6 (SE½)	1 Left Patella (3 pieces)	
116	2	11	1 Thoracic Vertebra (process)	Feature 2
116	2	11	1 Cervical Vertebra (process)	Feature 2
116	2	11	2 Left Ribs	Feature 2
116	2	11	3 Rib Fragments	Feature 2
116	2	11	1 Distal phalanx (hand)	Feature 2
116	2	11	1 Coccygeal element (C2?)	Feature 2
116	2	11	1 Left Pubis/Ischium fragment	Feature 2
116	2	11	1 Scapula Fragment (body)	Feature 2
116	2	11	1 Ilium fragment	Feature 2
116	2	11	1 Cranial fragment	Feature 2
116	2	11	1 Right Scapula fragment (coracoid)	Feature 2
184	3	5	1 Right Mandibular Incisor (lateral)	
215	5	7	1 Left Patella	No lipping, fairly large
212	5	8	1 Right Humerus (distal)	Small, no septal apeture
233	5	10	1 Middle Phalanx (hand)	
241	5	11	1 Left Third Metacarpal	
255	5	12	1 Femur/Humerus head	
232	5	N. wall cleaning	2 Thoracic Vertebrae	Young child, 1-3 years
276	6	6	1 Tooth	Left maxillary premolar?
276	6	6	1 Pubis (?) fragment	
288	6	8	1 Right Scapula	young child, 1-3 years
315	6	11	1 Proximal Phalanx (foot)	Feature 2?
315	6	11	1 Right Temporal	Zygomatic process, Feature 2?
323	6	12	1 Left Zygomatic	Feature 2?
318	7	ST. 3	1 Left Parietal	Feature 2
262	4	4	1 Right Parietal	older ind., squamosal suture partially fused
129	4	4	1 Left Humerus	
129	4	4	1 Right Fourth Metatarsal	
131	4	5	1 Proximal Phalanx (Foot)	
131	4	4	1 Cranial fragment (frontal?)	
136	4	6	1 Lumbar Vertebra (3 pieces)	moderate lipping on inf./sup. articular surface
136	4	6	1 Sternal fragment	Manubrium?
136	4	6	1 Ilium (?) fragment	
141	4	7	2 Distal Phalanges (Hand)	Feature 3
141	4	7	1 Middle Phalanx (Hand)	Feature 3
141	4	7	1 Mandibular Central Incisor (?)	Feature 3, enamel almost entirely worn away
140*	4	7	5 Rib fragments	Feature 3
140	4	7	1 Left Third/Fourth Rib	Feature 3
140	4	7	2 Right Femur fragments	Feature 3
140	4	7	1 Right Third Metacarpal	Feature 3
140	4	7	1 Distal Phalanx (Hand)	Feature 3
140	4	7	1 Right Navicular (Hand)	Feature 3
140	4	7	1 Right Lesser Multangular	Feature 3
140	4	7	1 Right Hamate	Feature 3
140	4	7	1 Lumbar Vertebra	Feature 3, mild arthritic lipping, some deterioration

Note: All material from Bag 140 was identified in the field and reburied with the unexcavated remainder of Feature 3.

2,300 years of repeated short-term occupations. It is unlikely that all of the individuals in any given strata set were living contemporaries. In addition, there seems to be no evidence for repeated, systematic use of particular areas within the cave for interment or other disposal of the dead. The site, though it contains human skeletal remains that include at least five individuals, is not considered to be a cemetery or ossuary site.

Interestingly enough, though other analyses indicate that use of the cave was more frequent or more intensive during the Late Woodland period represented in Strata Set A, no human skeletal remains were recovered from levels assigned to this strata set. This finding reinforces the interpretation that the site was used as a generalized short-term residential camp during the Archaic periods, but that its function became more specialized during the Late Woodland period. If the site is being used as a general-purpose, but short-term residence, it is logical to bury an individual in the location where s/he died and move on to other residential sites in the settlement system. If the site is being used for a limited set of activities and the occupants do not represent the complete social unit, it is also logical that anyone who died while the site was being occupied for its specialized function might be removed and disposed of in a more complete social context, such as a base camp habitation site or a specialized mortuary site.

Discussion and Integration of Analyses

The analyses presented in the above sections have attempted to examine the paleoenvironmental and cultural context of Sadie's Cave. Analyses were presented that formed an initial baseline of general climatic and paleoenvironmental conditions (snail shell and mussel shell analyses), and other data sets were examined that were increasingly affected by cultural rather than environmental variations (botanical remains, vertebrate faunal remains, lithic and ceramic artifacts). Finally, the remains of some of the people who presumably occupied the cave (they were at least buried there) were analyzed. All of these analyses had as their common goal the documentation of changes in environmental conditions, cultural systems and the relations between these two systems throughout the Holocene. This section provides an overall integration of these independent analyses.

Analysis of terrestrial gastropods showed a clear response in local environmental conditions to the warmer and drier conditions of the Hypsithermal Interval. The moist conditions that prevailed during the early Holocene (Strata Set E) gave way to drier conditions on the hill-slope location during the mid-Holocene Hypsithermal. At the same time that drier conditions were initiated, increased deposition of eroded hill-slope sediments resulted in accumulation of Strata Set C sediments near the cave mouth. Dry conditions continued to prevail during the middle to late Holocene period represented by deposition of Strata Set B sediments (3,800-5,000 years ago); the local environment probably included upland prairie and savanna vegetation. The upper late Holocene sediments of Strata Set A show an amelioration of environmental conditions and return of a more mesic woodland vegetation community to the local Sadie's Cave environment. This record of changing Holocene environmental conditions is replicated at other stratified sites in the region. The gastropod assemblages show major changes in species composition through time, which suggests that the impact of the Hypsithermal was locally severe. The environmental changes may have been of sufficient duration and severity to have affected the local cultural systems. The attributes of the cultural system that would have been most directly affected are subsistence and settlement patterning.

The mussel shells from Sadie's Cave represent a culturally selected set of natural resources whose attributes and species composition also reflect local fluvial conditions. Analysis of snail shells indicated that the Hypsithermal interval had a relatively severe impact on terrestrial resources; analysis of mussel shells showed additional, congruent changes in fluvial conditions during the Holocene. Changes in species composition, species diversity and habitat preferences all indicate a decreased water discharge in the Big Piney River during the middle and early late Holocene periods represented by strata sets B and C. The changes documented at Sadie's Cave (and Miller Cave) are replicated in other mussel assemblages from the northern Ozarks, indicating again that the Sadie's Cave data are part of long-term regional trends that potentially had widespread and long-term impacts on human cultural systems.

Faunal exploitation patterns remained generally similar through time, with possible subtle trends. Fish, reptile and amphibian use appears to increase during the Middle Archaic period only to drop off during the Middle-Late Woodland period. Turtle use, especially related to the use of aquatic species such as pond turtles and softshell turtles, appears to increase from the late Middle Archaic period onward. Interestingly, box turtle, a more terrestrial species, is only found in the late Middle Archaic assemblage. Bird use, alternatively, appears to remain relatively stable with the exception of an increase during the Middle Archaic period. Finally, mammal exploitation appears to remain stable to slightly increasing during the Archaic period, with a larger increase occurring in the Middle-Late Woodland period. In general, faunal exploitation was constrained by the immediate environment. Mammals were always the most important group of species, although fish use increased during the Middle and Late Archaic periods. Mammal exploitation centered on white-tailed deer, with smaller mammals such as woodchuck, muskrat and rabbit contributing to the diet. The Hypsithermal Interval does not appear to have had a major impact on faunal exploitation patterns.

Given that the terrestrial gastropods indicated relatively severe impact of Hypsithermal conditions on the local environment, it was expected that the botanical remains from Sadie's Cave would also show relatively noticeable changes in local vegetation through the Holocene. However, analysis of flotation-recovered archaeobotanical remains from all analytical units and strata sets shows little change in assemblage composition through time. The stability of the archaeobotanical remains is in part due to effects of small sample sizes, fragmentation of remains and the necessity of aggregating data by strata set. Cultural selection also has strongly affected the species composition in the archaeobotanical assemblage. The middle Holocene climatic changes probably resulted in a large increase in oak at the expense of hickory species in both the Ozark region in general and in the immediate locality of Sadie's Cave. However, it appears that the increased abundance and availability of oak was outweighed by the greater effort needed to process these acidic nuts. As a result, hickory nuts were apparently culturally selected for processing and were differentially introduced into the botanical assemblage in much higher proportions than their actual occurrence on the landscape. Hickory dominates the nutshell assemblage in all strata sets, masking the effects of the Hypsithermal impact on botanical subsistence resources.

It is of some interest to note that the wood charcoal assemblage does not show the same pattern as the nutshell. It appears that wood charcoal is not strongly affected by cultural selection, and the species composition of wood charcoal would thus be a better indicator of changes in local environmental and forest composition changes. Unfortunately, the wood charcoal at Sadie's Cave was highly fragmented, and identifiable fragments are few in number for all assemblages. However, oak is the dominant species in Strata Sets A, B, and D. This finding suggests that the expected

Hypsithermal environmental impacts did occur, but were outweighed by economic factors and patterns of cultural selection.

It is also of interest that Strata Set A shows a marked increase in the abundance and diversity of botanical remains. This is in part due to better preservation of the more recently deposited material, but also mirrors increases in density of other major material classes (lithic and mussel shell). Such systematic changes in artifact density indicate that the frequency or intensity of occupation was relatively stable and low during deposition of strata sets B, C and D but increased during the period represented by deposition of Strata Set A (Late Woodland). Detailed analyses of lithic debitage and modified items were carried out to further define the nature of these changes and to assess the changing function of the site in the local settlement system.

Lithic debitage analyses indicated that the materials contained in strata sets B, C and D, representing Middle and Late Archaic time spans, probably resulted from repeated short-term use of the site as a domestic habitation. The debitage profile for these strata sets is diverse and generalized, indicating that a wide range of lithic-reduction activities took place. No single, long-term occupation was evident, and the general interpretation is that the site function remained relatively stable as a short-term residential camp throughout this long time span. The debitage contained within Strata Set A, however, indicates a change in both the intensity or duration of occupation episodes, as well as a shift in site function. Debitage in this strata set becomes dominated by late-stage reduction flakes, which suggests a shift toward a narrower or more specialized set of lithic reduction activities. Increasing intensity/frequency of occupation and concomitant narrowing of the range of activities conducted suggests that the overall site function shifted as well. This pattern is consistent with use of the site as a short-term, specialized field camp in a logistically organized settlement system.

Analysis of modified items supports this interpretation of changing site function, and also provides some indication of the specific nature of the changes. Strata Sets B and C have assemblage composition and diversity that is consistent with use of the site as a generalized short-term habitation in a settlement system based on residentially mobility. There is a relatively rapid shift in Strata Set A toward an assemblage that is dominated by modified items that require more energy in their manufacture and maintenance; expedient modified items decrease and formally shaped tools increase in this strata set. There is also evidence for increased incidence of curated and potentially curated artifacts. Partially reduced, unfinished tools are much more common, and a cache of unfinished tools was recovered in Strata Set A. Use-wear analyses show evidence for a narrower range of kinetic motions; activities involving cutting come to clearly dominate the assemblage. High-magnification use-wear data (though limited) suggests that hide working was an important aspect of the activities.

All of these trends indicate use of the site in a more specialized way that resulted in repeated short-term, but more intensive, occupations. The site was probably occupied for a limited time during the year by a subset of the coresidential population. In addition, caching of materials suggests that the site was used repeatedly for the same set of tasks. These data collectively indicate that the site functioned as a specialized field camp in the local Late Woodland settlement system. Comparison of debitage and modified item assemblages from individual test units indicates that the use of space within the cave became more structured during this time. Late-stage lithic reduction

and biface caching took place near the back of the cave, while refuse disposal took place near Test Unit 2.

These analyses collectively indicate two major trends in assemblages at Sadie's Cave. First, the paleoenvironmental indicators show a clear impact on local resources and environments as a result of the onset and duration of the middle Holocene Hypsithermal interval. The local environment became warmer and drier, affecting local species composition of terrestrial gastropods, mussels and vegetation communities. Late Holocene communities attained their modern character and became established during the Late Archaic period, probably around 3,000 years ago. Overlaid on this pattern of changing Holocene environmental conditions is the second trend. The local settlement and subsistence systems were apparently very stable, even though the local environment may have been rather severely affected by Hypsithermal conditions. All evidence points toward relatively uniform use of the site as a short-term residential camp throughout the Middle and Late Archaic periods. Only in the Late Woodland period after about 1,700 years ago, is there any indication of changing site function or changes in the overall organization of the settlement system. In this period site use changes to a probable field camp in a logistically organized settlement system.

These two trends take place over the same span of time, but they are essentially independent of each other. There is no record of environmental change, either at the local or regional level, that would correspond temporally with or act to induce the changes in settlement system that took place during the Late Woodland period. The major implication derived from these observed trends is that the local cultural system may have been highly adapted to residential mobility, to the extent that even major changes in local environmental conditions were not sufficient to induce changes in settlement strategies and overall settlement system organization. Residentially mobile systems are highly flexible, and that is the key to their resilience and adaptability. It is possible that a residentially mobile settlement system, operating under conditions of generally low population density, would be flexible enough to maintain its overall systemic stability in spite of changes that affected the distribution, quality and quantity of local vegetation communities, aquatic habitats, and perhaps terrestrial vertebrate communities.

This resiliency can easily be interpreted as evidence for cultural conservatism. Brown (1984) has argued strongly and convincingly against the concepts of cultural conservatism and cultural marginality in regards to late prehistoric developments in the Ozarks. However, the evidence from Sadie's Cave suggests that prior to the Late Woodland period (before about 1,700 years ago), the local cultural adaptations may have been highly resilient and adaptable. This permitted residentially mobile settlement systems to be maintained in a relatively stable state for several thousand years. Under these circumstances, the concepts and possible archaeological signatures of cultural conservatism and regional adaptations need to be reexamined.

The causes of settlement system reorganization and shift toward logistical strategies remain unknown, but environmental variation is probably not a good candidate. It is more likely that social organizational changes, increasing contact with nonlocal cultural systems, increases in internal population or social density, or a combination of these or other nonenvironmental factors are responsible for this change. Regardless of the ultimate causes of these changes, Sadie's Cave contains a valuable record that documents both the changing Holocene environment and the changing cultural adaptations of the Archaic and Woodland periods.

Evaluation of Research Goals

An earlier section presented a series of six research goals for the investigations at Sadie's Cave. These research goals are discussed and evaluated in the following pages. Another overall project goal was to develop site preservation and stabilization plans for the site, should its research potential warrant such an effort. This goal will be addressed in Chapter 9.

Role of the Site in the Late Woodland Settlement System

Late Woodland cultural material was recovered from the Sadie's Cave surface and from the upper strata of all test units except Test Unit 1. The site witnessed extensive use during this time period. The first research goal was to determine the role of this site in the local Late Woodland settlement system. Markman (1993) suggested that the nearby Miller Cave may have functioned as a specialized burial location during the Late Woodland, and there was some suggestion that this function might be extended to Sadie's Cave and other cave sites in the local area. Analysis of lithic, faunal, shell, and plant remains indicate that the site functioned as a specialized field camp in a logistically organized settlement system during the Late Woodland period. The precise nature of the occupation and the specific activities carried out are unknown, but they involved use and storage/curation of bifacial tools, cutting and scraping activities, and late-stage biface production and maintenance. While burials were documented at the cave, none were associated with the Late Woodland occupations. These findings indicate that Markman was partially correct in his hypothesis. The site did function as a locus of more specialized activities during the Late Woodland period. However, whatever the specific activities carried out at the site may have been, they did not involve burials, and there was no evidence of other types of mortuary-related behavior. The site did not function as a specialized burial/mortuary location.

Building Local and Regional Chronological Sequences

The stratigraphic separation of deposits in the eastern third of the cave provided an excellent opportunity to build and test local and regional cultural chronological sequences. A total of 17 radiocarbon assays was obtained for various depositional contexts within Sadie's Cave, providing excellent internal control of stratigraphy and chronology. This aspect of the chronological goal was met. Unfortunately, most of these assays were not directly associated with temporally diagnostic artifacts, so they are of limited utility for refining local cultural chronology. In addition, at least four of the projectile points from excavation contexts show evidence of having been recycled by much later inhabitants of the site and redeposited outside of their original context of manufacture and use. However, some direct correlations can be made between projectile point types and associated radiocarbon assays.

First, TU5/L9 produced a point that was classified as a Williams or Category CN3 (McMillan 1965) type. A radiocarbon assay of 3800$\pm$90 B.P. was obtained on carbon from the same level. This point has an acuminate tip, which McMillan (personal communication) associates with Late Archaic resharpening patterns. The radiocarbon assay confirms his general observation and may provide opportunities for comparison with other dated specimens and refinement of the regional expanding-stem point typology.

Second, a contracting-stemmed point base assigned to the Gary or Adena cluster was recovered from TU6/Level 2 (Stratum 1B). Carbon from this level produced an assay of 1670±70 B.P. This Middle Woodland age is consistent with recovery of the contracting stem point. In addition, a straight-stemmed point was recovered from Level 3 (Stratum 1C) of the same test unit. This point was assigned to the Verkamp stemmed or SS4 category (McMillan 1965; Roberts 1965). The date of 1670±70 B.P. from the defined substratum above this point indicates that Verkamp points predate this general time range. This finding is consistent with regional trends in point typology that assign a variety of straight-stemmed points to a general straight-stemmed cluster (Justice 1987) that generally dates to Terminal Archaic to Early Woodland temporal ranges (2,600 to 2,000 years ago). While the Sadie's Cave point is not directly dated, it does provide additional data on possible temporal ranges for this point type.

Finally, other direct dates and bracketing dates from Sadie's Cave contexts that produced projectile points confirm the existing temporal ranges for Big Sandy points (Middle Archaic in age; TU6/Level 9 dates between 6,500 and 7,700 years ago. These data, while not definitive of new point types or entire chronological sequences, do provide additional temporal control of regional and local point types. Additional dates, as usual, are badly needed.

Reconstruction of Subsistence Patterns and Assessment of Site Function

The excellent preservation of bone and shell remains and the presence of carbonized plant remains in some abundance provided an opportunity to reconstruct subsistence patterns associated with specific strata sets. These data indicate that the subsistence was fairly generalized for Strata sets B and C, which indicates that the occupations contained within these strata probably represent the remains of short-term domestic habitations. In Strata Set A, there is an increase in density of mussel shell and a decrease in bone by weight. This finding is consistent with a shift in use of the site toward more specialized sets of activities. There is reliance on gathered plant remains throughout the occupational sequence; domesticated plants are represented only by a few squash/gourd remains recovered from Strata Set A. The squash/gourd remains may represent containers rather than subsistence items. If so, this reinforces that the role of the site changed during this time period to reflect a more specialized set of activities and perhaps storage of materials related to that specific set of activities.

These patterns of plant use correlated well with other indicators of settlement system organization (lithic reduction profiles, artifact density and functional diversity data for modified items). Analyses of these artifact classes indicate that the site was probably used only sporadically as a short-term resource extraction location during the Early Archaic period (Strata Set E). Subsistence remains and all other artifact classes show low densities and reflect low diversity of activities. There is an increase in sedimentation rates and occupational intensity associated with deposition of Strata sets B, C and D. These trends reinforce the impression that the site was used for repeated, short-term, general domestic habitation during the Middle and Late Archaic periods. Debitage profiles reflect generalized use of the site, but density of artifacts is still fairly low. Modified items are diverse, similar to other assemblages on Fort Leonard Wood that have been interpreted as generalized domestic habitations. In Strata Set A, artifact density increases, and there ratios of lithic, bone and shell artifacts change, indicating a shift in both the intensity/frequency of site use and the function of the site. The debitage profile reflects an emphasis on late-stage reduction, and the modified item assemblage becomes less diverse. There is an apparent emphasis

on activities involved with cutting and scraping soft materials. Partially reduced, but unused, modified items increase in abundance, and there is evidence for some of these items being cached for later use at the site. Collectively, these trends are consistent with the subsistence-related assemblages, and indicate that the function of the site shifted toward more specialized and more frequent use during deposition of Strata Set A (Late Woodland period). The site probably functioned as a field camp in a logistically organized settlement system during this time span.

These findings have broader implications for regional trends in settlement systems. It appears that prior to the Late Woodland occupations, the local settlement system was consistently organized as a residentially mobile system. At the beginning of the Late Woodland period (about 1,700 years ago), there is an apparently abrupt shift toward logistically organized settlement, with activities revolving around long-term base camps. The rapidity of this change may be an artifact of the depositional rates at Sadie's Cave. There is a gap in the radiocarbon dates of about 2,100 years (3800 to 1700 B.P.) which corresponds to the interface between Strata sets A and B. Little is known about this time period from either Sadie's Cave or from other sites in Fort Leonard Wood. It is likely that the shift from residentially to logistically organized settlement took place more gradually at some time within this temporal and occupational gap in the Sadie's Cave record.

Paleoclimatic and Paleoenvironmental Record

The major stratigraphic divisions within the site span the mid-Holocene, a time period assumed to have been affected by warmer and drier regional (and global) climatic conditions. This period is known as the Hypsithermal Interval, and its effects have been documented at other sites in the region. Preserved bone, shell and carbonized plant remains were analyzed for evidence of paleoenvironmental and paleoclimatic changes. The terrestrial gastropods from the site clearly document a strong local Hypsithermal impact, with climatic conditions shifting from cooler and moister parameters (Strata Set E) and becoming more droughty during the middle and late Holocene. The vegetation community probably became more xeric; a prairie/oak savanna environment is indicated near the cave during deposition of Strata sets B and C, and mesic woodland conditions are established at the site by the Late Woodland period. Mussel shell analyses indicate that the droughty conditions of the middle Holocene were severe enough to have affected the local aquatic environments. The botanical assemblage is highly fragmentary, and it adds little to our understanding of paleoenvironmental changes. However, oak species seem to dominate, especially in Strata Set B, which is consistent with more xeric vegetation regimes during this time span. Strata Set A has a more variable species composition and indicates the modern mesic side-slope forest community was established by this time. The faunal assemblage shows mainly species adapted to the Eastern Woodlands and only a few of the grassland species that might be expected during the Hypsithermal Interval.

These data collectively indicate that the Hypsithermal Interval had a noticeable impact on local environmental conditions during the middle and late Holocene. These data are consistent with trends observed at other sites in the region (Rodgers Shelter and Modoc Rock Shelter) that also document paleoclimatic changes during the Middle Archaic period.

Effects of Paleoenvironmental Changes on Human Cultural Systems

Human responses to the impact of the mid-Holocene drying period may have included population aggregation in favorable landscape settings, development of more logistically organized settlement systems, changes in technological efficiency as a result of decreased group mobility, and changes in dietary preferences. All of these cultural responses to changing environmental conditions have been documented in other localities in the region (lower Illinois River valley, Modoc area in the central Mississippi River valley, and at Rodgers Shelter in southwest Missouri). In these other localities, the Hypsithermal appeared to have resulted in changes in overall vegetation community composition and distribution of vegetation across the landscape. These changes in turn affected the organization of human settlement systems. However, the effect of environmental changes on cultural systems in the Fort Leonard Wood area remains to be established but can be investigated through analysis of the cultural remains preserved in Sadie's Cave. The settlement system was probably based on residential mobility and it appears to have remained essentially unchanged throughout the Middle and Late Archaic periods. It is only during the Late Woodland period that there is evidence for a shift toward logistical organization of settlement.

It appears that the effects of the Hypsithermal impact, though noticeable and potentially locally severe, were not drastic enough to have affected the organization of settlement and subsistence practices. As noted above, the hallmark of residentially organized settlement is its high degree of flexibility in the face of shifting resources (see Ahler 1984). This characteristic may have helped to maintain what appears to be a stable settlement system for several millennia. Wood and McMillan (1976) and McMillan and Klippel (1981) developed hypotheses regarding the impact of the Hypsithermal on central Missouri human populations and adaptive strategies. They argued that the central Missouri area should exhibit strong evidence of paleoenvironmental changes associated with the Hypsithermal Interval, and this does appear to be the case at Sadie's Cave. However, the predicted effects of these changes on human settlement (increasing duration of occupations, development of base camps and logistical settlement systems, and increasing emphasis on renewable aquatic resources) are not demonstrated in the Sadie's Cave record.

There may be several reasons for long-term stability in the settlement system and an apparent buffering of the effects of the Hypsithermal. It has been pointed out in other studies (Ahler and McDowell 1993) that the karstic drainage system and limited surface water availability may have acted to restrict settlement to areas near permanent streams, regardless of the time period or the type of settlement system organization. This effect of permanent water sources may also have promoted stabilization of the settlement system in general into a highly flexible system based on residential mobility.

Another factor to consider is the effect of stream sizes on the abundance of aquatic resources. In many of the areas that show major changes in settlement organization that are correlated with the Hypsithermal Interval, the changes in settlement and subsistence have been attributed to development of backwater lakes and consequent increasing abundance of aquatic resources, which acted to pull settlement toward major river valleys with seasonally renewable resources (fish, mussels, etc.). The effects of upland resource degradation are seen as much less important in developing logistical settlement systems during this time. In the Fort Leonard Wood area, stream gradients are steep and streams are confined to narrow valleys. Seasonally flooded backwater lakes and wetlands are much rarer than in the major river valleys of the region. The environmental pull toward the resource-rich

major stream valleys may not have been a factor in the Fort Leonard Wood area because of the predominance of swift-flowing, shallow streams.

Finally, we cannot forget the potential effects of the nearby Miller Cave. Faced with a choice of caves that are only 80 m apart on the same topographic feature, it is logical to pick the larger and better illuminated cave for longer-term occupation. Sadie's Cave never exhibits long-term occupation in any stratum, while there is evidence for much longer and more intensive occupation of Miller Cave during most of the Holocene. For these reasons, the occupational record at Sadie's Cave may be anomalous in that it may always represent a small subset of the activities that were performed in the nearby Miller Cave. The sequence of inferred site functions and changes in settlement organization may not be representative of the general regional trends.

Relationships Among Miller Cave Complex Sites

The sixth research goal was to investigate the temporal and functional relationships between Sadie's Cave and other sites in the Miller Cave Complex, especially Miller Cave itself. Miller Cave contains evidence of occupation during the Early Archaic, Middle Archaic, Late Archaic, and Late Woodland periods. No data are available regarding the function of this site during the latter three time periods because of the excavation methods used in the initial investigation of the site (Fowke 1922). However, the Early Archaic occupation seems to represent a generalized, possibly residentially oriented occupation(s) (Markman 1993). This contrasts with the Early Archaic occupations at Sadie's Cave, which are interpreted as representing only sporadic use of the site as a resource extraction location. The functions are not the same, but instead appear to be complementary aspects of a residentially mobile settlement system. These differences may be related to the fact that Miller Cave is larger than Sadie's Cave and would accommodate more people for longer periods of time. This relative inequality between the two sites may have been a consistent aspect of local settlement systems throughout the Holocene. For example, if Miller Cave functioned as a long-term base camp (perhaps during the Middle Archaic), occupation of Sadie's Cave increased, but the assemblage still looks like a short-term residential camp because the majority of activities were carried out in Miller Cave. This relationship between Miller and Sadie's cave could also explain why there is apparent stability in the site function for Sadie's Cave, even though the Hypsithermal Interval clearly affected patterns of regional resource distribution and abundance. More drastic changes in middle Holocene settlement organization may be evident at Miller Cave.

During the Late Woodland period, after logistically organized settlement systems clearly had been established in the region, the relationships between Miller and Sadie's caves become more complex. Neither site appears to have functioned as a base camp; long-term occupation probably took place in valley floodplain settings. Instead, both sites appear to represent specialized occupations that are part of an integrated and complex settlement system that may have involved all of the sites in the Miller Cave Complex. Miller Cave may have functioned as a specialized mortuary location during this time period (see Markman 1993), while Sadie's Cave functioned as a short-term field camp or storage/caching facility. A cairn on the bluff crest (23PU254) probably represents another specialized Late Woodland mortuary facility which may contain individuals of different social rank than those buried in Miller Cave. Recent investigations at 23PU288 (Kreisa 1995), located on the bluff crest above Miller and Sadie's Cave show that most of the occupation can be assigned to the Middle and Late Woodland periods. Activities at this site appear to focus on late-stage bifacial reduction, and there is evidence of spatial segregation of activity areas or components within the site.

Finally, the Miller Petroglyphs (23PU255) are probably also late prehistoric in age, and may represent a ritual or ceremonial site or an identifying marker for the local population aggregate. It appears likely that all of the sites in the Miller Cave Complex are functionally related as integrated and complementary components of a logistically organized Late Woodland settlement system.

Evaluation of Site Potential

The excavations and analyses described above clearly demonstrate that Sadie's Cave contains scientific information of considerable significance to regional research issues. The importance of the site is expressed in terms of its potential for continued contribution to three major research issues.

First, the site contains a record of paleoenvironmental change that spans most of the Holocene. Such records are rarely preserved and can be used to reconstruct local paleoenvironmental conditions and to compare regional and panregional trends. Second, the site contains a record of human occupation that also spans most of the Holocene. In addition, the functional roles of these occupations in the local settlement system have been established fairly well, which allows these occupations to be compared with other contemporary components within the region. Third, the site is apparently functionally related to Miller Cave throughout its occupational history, and is probably functionally related to several other Late Woodland sites in the Miller Cave Complex. Functional relationships among sites are difficult to document, and this systemic relationship among contemporary sites enhances the scientific significance of any one site. If the system is greater than the sum of its parts, the scientific significance and research potential of each component of the system is increased by being part of the system. The proposed functional relationships among the Miller Cave Complex sites should be explored further through testing at other sites on the bluff crest and possibly at the base camp habitation sites in the Big Piney River floodplain.

PART III

RESEARCH SUMMARY, SITE EVALUATIONS, AND RECOMMENDATIONS

CHAPTER 8
RESEARCH SUMMARY

In Chapter 4, four general research themes were developed that are common to all of the sites investigated in this project. This chapter provides an assessment of the first three of these general research goals and addresses the relative success of the project in meeting them. The fourth research goal, development of preservation and stabilization plans for each site, is discussed in more detail in Chapter 9.

Spatial Proximity and Functional Relationships

Because the sites are in close spatial proximity to each other and form what has been described as a site complex, it was assumed that the sites are either temporally or functionally related to each other. The first general research goal was to explore the validity of this assumption. The results of the Phase II testing and this research confirm that all three sites investigated here have Late Woodland to late prehistoric components. In addition, both Miller and Sadie's caves share similar depositional and occupational histories. Both sites were occupied during the Early Archaic, Middle Archaic, Late Archaic, and Late Woodland periods, indicating that at least these two sites in the Miller Cave Complex are temporally related.

Functional relationships among these sites is a more complex issue, but the above discussions of Sadie's Cave suggest that both Miller and Sadie's Cave were functionally related throughout their occupational history. However, the analyses also indicate that these sites did not function in the same manner at any time in their common cultural history. Miller Cave, because of its larger size and better illumination, was probably more intensively or frequently occupied than Sadie's Cave, regardless of the time period being considered. This assertion can be demonstrated for the Early Archaic occupations—Miller Cave is interpreted to have functioned as a residential camp, while contemporary Sadie's Cave occupations indicate extremely short-term and sporadic use, perhaps as a resource extraction location. Though there are no quantitative data available for comparison, the range and quantity of Middle and Late Archaic artifacts recovered from Miller Cave suggests that it may have functioned as a base camp or was at least more intensively occupied than was Sadie's Cave during the same time span. Middle and Late Archaic occupations in Sadie's Cave are interpreted as a series of short-term residential camps, and there is no evidence for long-term or intensive occupation.

During the Late Woodland period, these sites both served as specialized field camps in a logistically organized settlement system. Again, their specific roles in the settlement system appear to be different. Miller Cave may have functioned as a specialized mortuary site, while Sadie's Cave appears to have functioned as a storage/caching location and as a field camp involved with processing locally collected materials. The Miller Petroglyphs appear to have served a ritual, ceremonial or instructional function in the Late Woodland to late prehistoric settlement system. The main habitation sites in this local settlement system are probably 23PU3 and 23PU4, which are large sites located on elevated terrace formations in the Big Piney River valley south of the Miller Cave Complex.

This research goal appears to have been met. The results of these investigations show that at least during the Late Woodland period, all of the investigated sites are related in a complex local settlement system. This finding enhances the research potential of each site.

Data Collection

The second research goal was to collect enough information and artifactual data from undisturbed contexts at all sites to be able to address the primary research issue stated above. Artifacts, spatial information, ecological data, and sedimentary data were collected and analyzed to address functional and temporal relationships among the sites and other site-specific research questions. All excavated samples were extracted from documented, controlled, intact stratigraphic contexts whenever possible, and were analyzed to provide maximum information on temporal, functional, and environmental aspects of each site. Data analysis of materials from Miller and Sadie's caves followed an interdisciplinary approach, which maximized extraction and comparison of environmental, sedimentary and cultural trends. These data collection and analysis procedures permitted temporal and/or functional relationships among the sites to be explored, thus, the second major research goal has been met.

Evaluation of Site Integrity

The third research goal common to all sites was to use the existing site documentation and additional information collected during this project to formally evaluate the integrity and condition of each site. These actions were initiated, resulting in an assessment of damage incurred at each site as a result of both scientific investigations and unsystematic artifact collection.

Miller Cave

Miller Cave has been severely impacted both by previous professional excavations (Fowke 1922; Markman 1993) and by artifact collectors. These actions have resulted in disturbance of approximately 70 to 80 percent of the site area and volume. The portions of the site that remain undisturbed are primarily located in the Southwest Lobe in poorly illuminated areas. The Southwest Lobe contains deposits that are at least Late Woodland in age; older cultural deposits may also be present in intact stratified contexts. Areas in the Main Chamber that are near the pond at the back of the cave have experienced surface disturbances, but some deeply buried deposits remain intact. At least some of these deep remnants are Early Archaic in age (Markman 1993). The coring program conducted in the present project identified the general location, depth, and extent of intact deposits in the Main Chamber and Southwest Lobe portions of the cave; side passages and small chambers were not explored. In addition to the areas mentioned above, the coring program located a small area of shallowly buried intact deposits in the Main Chamber. This area had been protected from excavation by a series of large rock falls.

In spite of the damage inflicted on the site by previous activities, it is our interpretation that a considerable portion of the site remains intact and contains potentially significant scientific information. As in most cave sites in Fort Leonard Wood, the site contains a stratified depositional sequence that contains lithic and ceramic artifacts, bone, mussel shell, and plant remains. In

addition, these materials are very abundant at Miller Cave, providing a rich assemblage through which to explore future research questions. The research potential of the intact portions of the site is very high, and additional investigations could yield important information relevant to both cultural and paleoenvironmental trends.

Miller Petroglyphs

This site is the most severely damaged of those that comprise the Miller Cave Complex. Vandals or artifact collectors have removed the engravings from the faces of all of the modified rocks, and additional damage has been done by painting and carving historic graffiti and names over the prehistoric designs. Of the 25-30 original engravings, only 13 complete and four partial engravings remain. About 70 percent of the surface of Rock 8 and 50 percent of the surface of Rock 9 have been removed. Rock 6 has been less severely vandalized, but the engravings on this rock have been adversely affected by natural weathering processes. Because of the high degree of vandalism, the site is assessed as being in poor condition. Vandalism is likely to continue in the future unless effective site protection measures can be implemented.

Again, in spite of the vandalism and damage, the site still has potential for contributing to our scientific understanding of the Fort Leonard Wood cultural resources. The motifs depicted on the rocks have been interpreted as vulvar motifs (Diaz-Granados 1993), a style commonly found at Late Woodland and Late Prehistoric petroglyph sites in Missouri. She has interpreted this motif class as representing a female symbol and has suggested that it may be symbolically linked with a female mythological character. The engravings at the site were apparently placed there during the Late Woodland period, which links this site both temporally and functionally to others in the Miller Cave Complex. This symbolic aspect of the site and its temporal affiliation with the Late Woodland occupations of the area serve to enhance the scientific potential of the site itself and the Miller Cave Complex in general.

Sadie's Cave

This site is the least disturbed of those investigated in this project, and it contains a record of cultural and environmental changes that span the Holocene. Early Archaic, Middle Archaic, Late Archaic, and Late Woodland periods are represented, and the site is linked both temporally and functionally to others in the Miller Cave Complex.

Damage to the site is minimal. What was once interpreted as a looter pit along the south cave wall is now considered to be part of the natural internal drainage features of the site. Two other large looter pits are present, and several smaller pits reveal evidence of undocumented excavation. Including the seven test units excavated by the University of Illinois (1993 and 1994 excavations combined), about one percent of the total site area has been disturbed. If only the eastern third of the cave that contains stratified deposits is considered, the documented disturbances affect about three percent of the site area. These findings indicate that the site is presently in excellent condition. However, the site, like all caves and rock shelters on Fort Leonard Wood, is at considerable risk for damage by artifact collectors and vandals. This site is the only known large cave on the fort that has not been severely impacted by looters. It is our opinion that if the site is left unprotected, it is only a matter of time before it suffers the same fate as other large cave sites in the area, with resultant loss of scientific and cultural information.

Based on the recovery of scientifically significant information, low incidence of damage and the potential for making continued contributions to our understanding of local and regional cultural research issues, Sadie's Cave is considered to have both high integrity and high research potential. The site is also at risk for damage through looter excavation. Accordingly, it is recommended that the site be protected to prevent unprofessional and uncontrolled excavation of these important deposits.

Summary

All three of the major research goals outlined above have been met as a result of our investigations. Because of their potential for containing additional scientific information and the high risk of damage to the site if left unprotected, site protection plans were developed for all three sites. These are summarized and discussed in detail in the next chapter.

CHAPTER 9
SITE EVALUATIONS AND RECOMMENDATIONS

The damage assessment information presented above can be combined with contextual information collected during excavations and other investigations and with the analyses and interpretations of collections to address the fourth common research goal of the project. The sites all contain scientifically significant information. In addition, they all continue to have considerable research potential for addressing local and regional research issues in future investigations. Finally, all of the sites are at risk of damage by uncontrolled looting because they are in a portion of the fort where public access is unrestricted and the sites are well-known features of the local landscape. For these reasons, site preservation plans were developed for all three of the sites investigated in this project.

The final general goal of the project was preparation of detailed site preservation plans that take into account the findings of the investigations regarding the information content of each site, the contextual integrity of the information, the amount and nature of existing damage to the site, the potential of each site to produce additional scientific information important to regional research issues, and the potential temporal and functional relationships among the investigated sites. Under these conditions, all of the sites met the criteria for developing site preservation plans. Actual implementation of the site preservation plans is not part of this project, but the preservation plans developed are sufficiently detailed that implementation should require little or no additional site evaluation.

Another factor to consider when developing site preservation plans was the stated desire of the Fort Leonard Wood Cultural Resource Manager to maintain public access to these sites. It was not feasible to simply close the sites off from access, partly because Miller Cave has historically been a place where people come to enjoy the view and spend relaxation time, and partly because it would be nearly impossible to restrict access effectively to either Miller Cave or Miller Petroglyphs. Sadie's Cave is less well-known, and access to this cave is more easily restricted than for the other two sites. Given these factors, the following site-specific preservation plans were developed. Each plan is tailored to the physical attributes and scientific significance of a specific site.

Miller Cave Preservation Plan

Based on the coring data that define the location and thickness of intact deposits within the cave, several zones can be defined, the scientific potential of which range from high to nonexistent. These zones are depicted in Figure 10, and are labeled according to the preservation class system developed and explained in Chapter 5. This figure is reproduced as Figure 56 for easy reference. Preservation classes range from V to I, with Class V representing highest potential. Of interest at Miller Cave is preservation of areas of the site that contain Class V and Class IV deposits.

It is our interpretation that the southwest lobe of Miller Cave has the highest potential for containing intact deposits that are of significance to regional research issues. The intact deposits are consistently thicker and in some locations show no evidence of previous disturbance. In addition, a 6-m wide zone on the southeast edge of the pond also has high potential, but the intact deposits here are buried by up to 40 to 80 cm of previously disturbed overburden. Both of these areas are

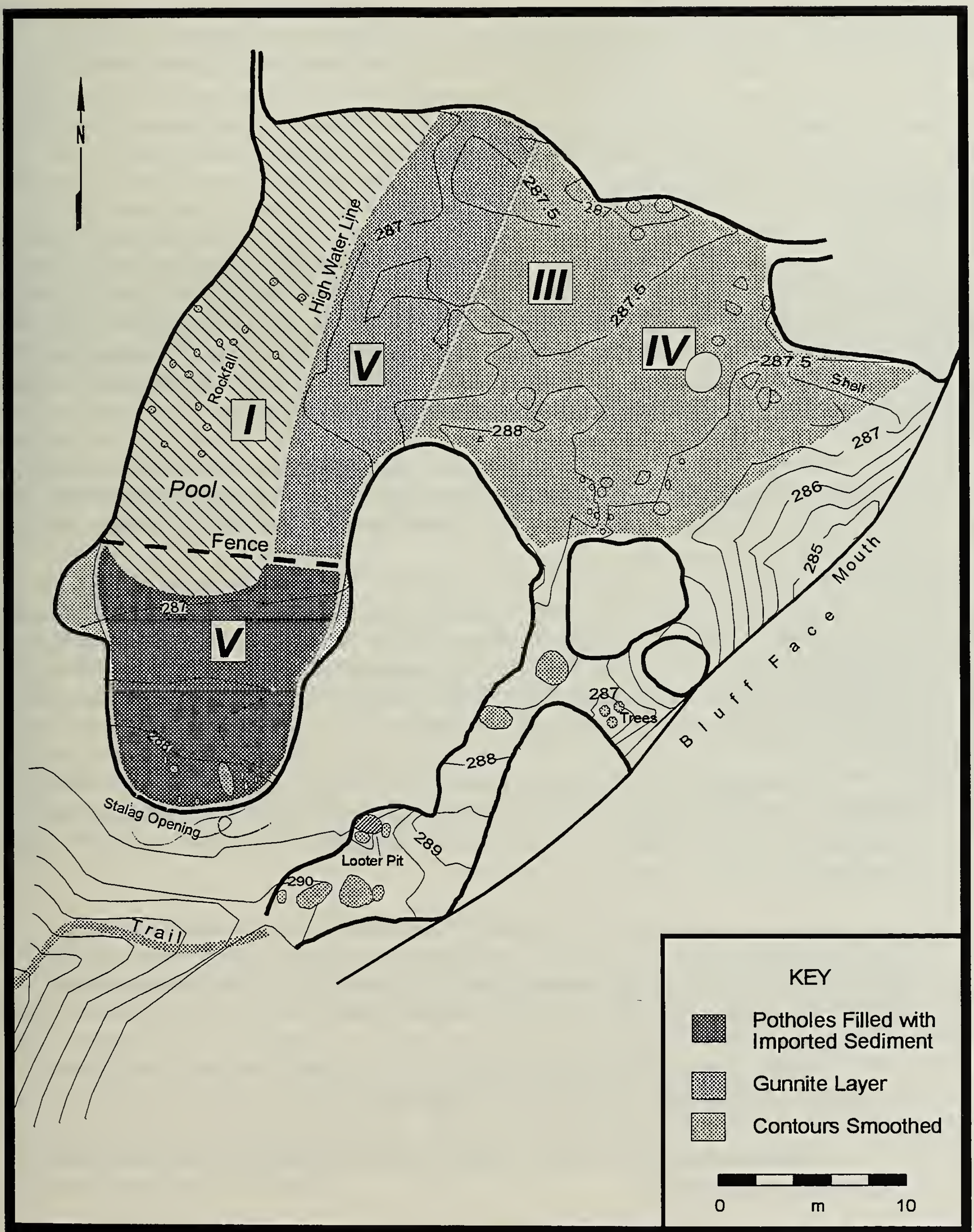


Figure 56. Distribution of Deposits by Preservation Class within Miller Cave and Proposed Site Protection Measures.

considered to contain Class V deposits. A small isolated pocket of buried intact deposits was located in the front third of the cave near a large rock fall. This location is of limited extent and has been partly disturbed by Fowke's excavations. It is considered to represent preservation Class IV deposits. The remainder of the deposits within the cave are disturbed and have little archaeological potential or significance to the region beyond providing artifact faunal, and botanical assemblages that have no contextual integrity. These areas are considered to contain Class III deposits. The pond area at the back of the Main Chamber contains little or no archaeological material and is considered a Class I zone.

After classifying the internal site deposits into various preservation classes, several approaches were discussed regarding specific site preservation and stabilization procedures. The specific recommendations for site preservation were developed to fulfill simultaneous goals of 1) keeping the site generally accessible to the public; 2) preserving the integrity of deposits according to their preservation rank, and; 3) providing cosmetic repair to the Main Chamber and Southwest Lobe areas. The following specific courses of action were recommended:

A) The front portion of Miller Cave should be smoothed, removing the potholes and evidence of surface disturbance. This can be accomplished by raking and redistributing the existing disturbed sediments without inflicting damage on underlying intact deposits.

B) The remainder of the Main Chamber floor also should be smoothed, and the disturbed surface deposits can be mixed with a hardening agent to produce a "gunnite" surface. This action will produce a hardened surface about five cm thick composed of on-site sediments. This hardened surface will effectively seal lower, intact, Class V deposits and discourage vandalism.

C) Potholes in the Southwest Lobe should be filled with disturbed on-site sediments or with culturally sterile sediment imported into the site, and another gunnite floor may be prepared for this portion of the cave. This action will protect the Class V deposits in this part of the cave.

D) As an alternative to C), floor-to-ceiling and wall-to-wall steel bars with 6-inch openings between bars could be inset into the bedrock to create a barrier across the northern neck of the Southwest Lobe. This action will restrict access to that portion of the site with greatest integrity and least disturbance.

E) Warning signs should be placed on site to inform potential looters of the site protection measures and penalties for disturbing a site.

F) Information signs should be placed in the main chamber to enhance public education and awareness.

These recommendations were incorporated into a proposal for implementing the site preservation plans. This proposal was submitted to the Cultural Resource Manager at Fort Leonard Wood who approved the proposed site preservation plan and requested funding as a separate grant

from the Legacy Resource Management Program. Funding was awarded for this site preservation project in February 1995, and the project will be implemented in the summer of 1995 by the Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Miller Petroglyphs Preservation Plan

The data compiled during our investigations at Miller Petroglyphs was used to evaluate the site integrity and develop site preservation plans. As with Miller Cave, specific recommendations for site preservation were developed to fulfill the goals of maintaining public access while preserving the integrity of the site against vandalism. This goal was made more difficult because the engraved rocks are in a very exposed and prominent position on the landscape. Moreover, a commonly used trail that provides access from the bluff crest road to Miller Cave passes along the bedrock ledge in front of the engraved rocks. It is unlikely that the trail could be obscured or modified to prevent access to this already well-known site. In addition, the configuration of the bluff face and shelter overhang, and the location of the engraved rocks within the shallow shelter prevent installation of vertical bars that would prohibit access and still permit viewing of the rock art. Bars would have to be slanted outward at the base to avoid impacting the rock-fall blocks, and this would result in a narrower trail that would potentially be hazardous for visitors to traverse.

Given these conditions, a site preservation plan was devised that consisted of two integrated courses of action. First, information signs should be placed at and above the site. These signs will inform visitors of the nature of the site, provide some interpretation of the prehistoric rock art, include drawings of the prehistoric engravings as depicted by Fowke (1922) other site documentation, and inform potential vandals of the risks involved in damaging a site protected by federal law and military regulations. Second, monitoring of the site should be increased, especially for a few months following installation of the information signs. We have noted elsewhere (Ahler et al. 1995) that installation of warning signs in 1982–1984 apparently attracted attention to sites and resulted in increased vandalism rather than the hoped-for reduction in damage. Perhaps the wording of the signage can be presented as both informative and cautionary at the same time.

Sadie's Cave Preservation Plan

Given the potential importance of this site to local and regional cultural resource research and the fact that it has suffered very little damage as a result of vandalism, it is recommended that this site be preserved in its entirety and access to the site restricted as much as possible. Access restriction is more feasible for this site than for others in the Miller Cave Complex because the trail leading to Sadie's Cave branches off from the main trail from the bluff crest to Miller Cave, and the Sadie's Cave trail dead-ends at the site. Other access to the site is possible, but would require negotiating a series of rock faces that are each three to four meters high or rappeling from the bluff lip directly over the cave mouth.

Under these conditions, several recommendations can be made that, if followed, should result in adequate preservation of the site. Any appropriate site preservation and protection plan implemented at this site should include provisions to prevent vandalism, which is the most serious

problem that threatens the integrity of the site. Specific recommendations include the following actions

First, the trail leading to Sadie's Cave should be obscured or blocked. Several alternative measures can be taken to fulfill this aspect of the plan. The trail undulates along the side slopes of colluvial sediment cones that have accumulated on a bedrock ledge. This topography necessitated construction of the trail by cutting into the colluvial sediment in at least two places to produce a shelf. It would be easy to remove the flat shelf from the trail at crucial locations, restoring the original outward slope to the sediment cone, and resulting in a trail that is much more difficult to traverse. These actions would not affect any known site location, though samples of the colluvial cone sediments should be screened to test for the presence of artifacts. After the trail slope and topography has been altered, a mixture of noxious plants can be established as ground cover in the area. Poison ivy is already endemic to the area, and it can be encouraged. Prickly pear, nettles and greenbriar—all of which are locally endemic plants—could be planted on the slopes to deter foot exploration of the Sadie's Cave trail area. Once established, these plants would probably be an effective barrier against the casual explorer.

Second, "bat fences" or other heavy-duty fencing may be erected over the mouth of Sadie's Cave to restrict access. Bats roost in the cave occasionally, and a solid barrier would be inimical to bat life as well as impractical to construct and emplace. The cave mouth is a low, wide opening, and the upper edge of the mouth forms a shelf parallel to the ground surface. Given this configuration at the cave mouth, it would be feasible to set steel bars into the lower side of the cave mouth overhang at close (6-inch) intervals, and drive or set other steel bars into the ground directly below the upper set. The bars could then be welded together to form a relatively permanent barrier. This open barrier would allow access to the cave by bats and other animals, and would also prevent access to the cave interior. Such a measure should deter the more serious looters and protect the site from all but the most deliberate vandalism.

Third, a passive motion or metal detector with attached alarms may be placed at the cave mouth just inside the opening. This detector would alert authorities of intruders or ground disturbance activities without producing false alarms due to animal intrusions into the cave. Such a measure would act to further deter the persistent looter.

Finally, the site can be monitored more frequently by wildlife authorities or conservation police. Monitoring of Sadie's Cave can be done at the same time as visits to other sites in the same area. Any disturbances to the cave interior should be reported to, and investigated by, the Cultural Resource Manager for Fort Leonard Wood.

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APPENDIX A

DETAILED LIST OF MUSSEL SHELL FROM SADIES CAVE

Freshwater Unionid Mussel Shell from Sadie's Cave.

Strata Set	Analytical unit[1]	Bag no.	Unidentifiable shell (g)	Identifiable shell: Weight (g)	Count (NISP)[2]	Charred (NISP)[2]	Taxa[3]
A	TU2/S1	9	12	8.1	5	2	*Elliptio dilatata* (3L); *Strophitus undulatus* (1R); *Venustaconcha ellipsiformis* (1L).
A	TU2/S1	10	3.9	5.3	3	0	*Elliptio dilatata* (1L, 1R); *Lampsilis reeviana* (1L).
A	TU2/S1	12	6.6	11	5	0	*Alasmidonta viridis* (1L); *Elliptio dilatata* (1L); *Lampsilis reeviana* (1L); *Lampsilis* sp. (1R); *Venustaconcha ellipsiformis* (1R).
A	TU2/S1	14	0.5	-	-	-	
A	TU2/S1	15	-	43.3	1	0	*Lampsilis cardium* (1L).
A	TU2/S1	16	7.2	4.3	4	0	*Lampsilis reeviana* (1L, 1R); *Pyganodon grandis* (1L); *Venustaconcha ellipsiformis* (1L).
A	TU2/S1	18	0.6	-	-	-	
A	TU2/S1	59	4.4	0.8	2	0	*Elliptio dilatata* (1R); *Lampsilis reeviana* (1L).
A	TU2/S1	60	4.8	0.2	1	0	*Strophitus undulatus* (1L).
A	TU2/S1	63	-	12.3	2	0	*Elliptio dilatata* (1L); *Venustaconcha ellipsiformis* (1R).
A	TU2/S1	226	35.7	44.6	6	2	*Actinonaias ligamentina* (1L); *Lampsilis cardium* (1L, 1R); cf. *L. cardium* (1L); *Lampsilis* sp. (1R); *Venustaconcha ellipsiformis* (1L).
A	TU2/S1	227	2.5	2.4	3	1	*Elliptio dilatata* (1L, 1R); *Venustaconcha ellipsiformis* (1R).
A	TU2/S1	237	13.5	40.2	18	0	*Actinonaias ligamentina* (1L); *Alasmidonta marginata* (1L); *A. viridis* (1R); *Elliptio dilatata* (4L, 2R); *Lampsilis reeviana* (1L); *Lampsilis* sp. (1R); *Lasmigona costata* (1L); *Venustaconcha ellipsiformis* (3L, 3R).
A	TU2/S1	239	0.6	-	-	-	
A	TU2/S1	243	0.9	2.9	1	0	*Venustaconcha ellipsiformis* (1L).
A	TU2/S1	246	1	4.8	1	0	*Elliptio dilatata* (1R).

				Weight (g)	Count (NISP)[2]	Charred (NISP)[2]	Taxa[3]
A	TU2/S1	329	-	2.3	1	0	*Elliptio dilatata* (1L).
A	TU2/S1	330	-	2	1	0	*Venustaconcha ellipsiformis* (1L).
A	TU2/F112	236	8.3	45	2	2	*Cyclonaias tuberculata* (1L); *Ligumia recta* (1R).
A-B	TU2/L4	19	12.5	9.1	6	1	*Elliptio dilatata* (1L, 2R); *Venustaconcha ellipsiformis* (1L, 1R); Unionidae sp. (1L).
A-B	TU2/L4	251	3.1	9.5	3	0	*Elliptio dilatata* (1L); *Fusconaia flava* (1R); *Venustaconcha ellipsiformis* (1R).
A-B	TU2/L4	253	0.2	-	-	-	
B	TU2/S2	20	5.7	6.4	6	0	*Elliptio dilatata* (3L, 2R); *Venustaconcha ellipsiformis* (1R).
B	TU2/S2	21	2.6	4.7	5	1	*Elliptio dilatata* (1L, 1R); *Fusconaia flava* (1R); *Venustaconcha ellipsiformis* (1L, 1R).
B	TU2/S2	22	2	0.6	1	0	*Lampsilis* sp. (1R).
B	TU2/S2	101	4.3	2.9	2	0	*Lampsilis* sp. (1L); *Venustaconcha ellipsiformis* (1R).
B	TU2/S2	103	0.3	-	-	-	
B	TU2/S2	104	1.2	0.1	1	0	cf. *Alasmidonta viridis* (1L).
B	TU2/S2	171	4.6	0.2	1	0	*Elliptio dilatata* (1R).
B	TU2/S2	266	0.6	-	-	-	
B	TU2/S2	267	0.3	-	-	-	
B	TU2/S2	276	1.6	14.6	2	0	*Amblema plicata* (1R); *Fusconaia flava* (1L).
B	TU2/S2	278	0.3	-	-	-	
B	TU2/S2	286	0.8	1.1	1	0	*Lampsilis* sp. (1L).
B	TU2/S2	287	0.6	3.7	1	0	*Elliptio dilatata* (1L).

Stratum	Analytical unit[1]	Bag no.	Unidentifiable shell (g)	Identifiable shell: Weight (g)	Count (NISP)[2]	Charred (NISP)[2]	Taxa[3]
B	TU2/F104	261	0.1	-	-	-	
C	TU2/S3	23	3.5	4.8	3	0	*Elliptio dilatata* (1L); *Lampsilis* sp. (1L); *Venustaconcha ellipsiformis* (1L).
C	TU2/S3	24	0.1	-	-	-	
C	TU2/S3	25	8.5	4.8	3	0	*Venustaconcha ellipsiformis* (1L); Unionidae spp. (1L, 1R).
C	TU2/S3	26	0.3	-	-	-	
C	TU2/S3	27	2.4	1.4	1	0	*Venustaconcha ellipsiformis* (1R).
C	TU2/S3	61	0.9	-	-	-	
C	TU2/S3	107	0.2	-	-	-	
C	TU2/S3	109	0.6	-	-	-	
C	TU2/S3	110	4.9	3.5	1	0	*Elliptio dilatata* (1L).
C	TU2/S3	112	1.7	-	-	-	
C	TU2/S3	113	1	-	-	-	
C	TU2/S3	173	2.3	-	-	-	
C	TU2/S3	288	4	2.8	3	0	*Elliptio dilatata* (1L, 1R); *Lampsilis cardium* (1L).
C	TU2/S3	289	0.3	-	-	-	
C	TU2/S3	298	2.9	13.3	3	0	*Elliptio dilatata* (1R); *Pleurobema coccineum* (1L); *Venustaconcha ellipsiformis* (1L).
C	TU2/S3	300	0.4	-	-	-	
C	TU2/S3	308	-	0.4	1	0	*Elliptio dilatata* (1L).
C	TU2/S3	309	7	3.5	3	1	*Elliptio dilatata* (1L, 1R); *Fusconaia flava* (1L).
C	TU2/S3	310	0.9	0.7	1	0	*Elliptio dilatata* (1R).
C	TU2/S3	325	0.6	-	-	-	
C	TU2/F2	33	0.2	-	-	-	

Stratum	Analytical unit[1]	Bag no.	Unidentifiable shell (g)	Identifiable shell Weight (g)	Count (NISP)[2]	Charred (NISP)[2]	Taxa[3]
C	TU2/F2	34	0.2	-	-	-	
C	TU2/F2	38	-	1.4	1	0	*Elliptio dilatata* (1R).
C	TU2/F2	39	1.1	2.6	1	0	*Elliptio dilatata* (1R).
C	TU2/F2	47	5.4	5.5	1	0	*Lampsilis* sp. (1L).
C	TU2/F2	51	1	-	-	-	
C	TU2/F2	53	-	4	1	0	*Elliptio dilatata* (1R).
C	TU2/F2	62	0.1	-	-	-	
C	TU2/F2	115	1.9	-	-	-	
C	TU2/F2	116	6.6	3.1	1	0	*Elliptio dilatata* (1L).
C	TU2/F2	121	0.5	-	-	-	
C	TU2/F2	126	1.2	2.1	3	0	*Alasmidonta viridis* (1R); *Elliptio dilatata* (1R); cf. *Venustaconcha ellipsiformis* (1R).
C	TU2/F2	128	0.2	6.6	2	0	*Venustaconcha ellipsiformis* (1L, 1R).
D	TU2/S5	163	0.1	-	-	-	
D	TU2/S5	180	0.4	-	-	-	
D	TU2/S5	181	1.1	-	-	-	
D	TU2/S5	315	1.8	0.5	1	0	*Venustaconcha ellipsiformis* (1L).
D	TU2/S5	323	0.1	3.9	1	0	*Fusconaia flava* (1R).
E	TU2/S7	193	0.2	-	-	-	
A	TU3/S1	145	25.8	105.8	9	0	*Actinonaias ligamentina* (2L, 1R); *Alasmidonta marginata* (1L); *Elliptio dilatata* (1L); *Lampsilis reeviana* (1L); *Lasmigona costata* (1L); *Quadrula metanevra* (1R); *Venustaconcha ellipsiformis* (1R).
A	TU3/S1	147	-	0.4	1	0	Unionidae sp. (1L).

Stratum	Analytical unit[1]	Bag no.	Unidentifiable shell (g)	Identifiable shell: Weight (g)	Count (NISP)[2]	Charred (NISP)[2]	Taxa[3]
A	TU3/S1	148	13.6	14.4	7	0	*Amblema plicata* (1L); *Elliptio dilatata* (1L, 1R); *Lampsilis cardium* (1L); *Lampsilis* sp. (1R); *Venustaconcha ellipsiformis* (2L).
A	TU3/S1	149	2.7	4.6	4	0	*Elliptio dilatata* (1R); *Lampsilis cardium* (1L); *L. reeviana* (1L); cf. *L. reeviana* (1R).
A	TU3/F4	151	3.1	-	-	-	
A-B	TU3/L3	158	0.7	1.6	1	0	*Venustaconcha ellipsiformis* (1R).
A-B	TU3/L3	159	6.9	5.5	5	0	*Elliptio dilatata* (2R); *Fusconaia flava* (1L); *Strophitus undulatus* (1R); *Venustaconcha ellipsiformis* (1R).
B	TU3/S2	170	9.4	13.6	6	0	*Elliptio dilatata* (2L); *Fusconaia flava* (1L); *Pleurobema coccineum* (1L); *Venustaconcha ellipsiformis* (2R).
B	TU3/S2	183	10.5	13.6	9	0	cf. *Elliptio dilatata* (1L); *Venustaconcha ellipsiformis* (5L, 2R); Unionidae sp. (1L).
B	TU3/S2	184	1.4	1.7	2	0	*Elliptio dilatata* (1L); cf. *Fusconaia flava* (1R).
B	TU3/S3	198	0.7	1.1	1	0	*Elliptio dilatata* (1R).
B	TU3/S3	199	0.5	-	-	-	
B	TU3/F5	157	0.4	2.7	1	0	cf. *Lampsilis cardium* (1L).
E	TU3/L7	209	-	1.4	1	0	*Elliptio dilatata* (1R).
E	TU3/L7	210	0.1	-	-	-	
A	TU5/S1	118	3.1	-	-	-	
A	TU5/S1	119	<0.1	-	-	-	
A	TU5/S1	154	8.6	18.7	6	0	*Alasmidonta viridis* (1L); *Elliptio dilatata* (1L, 1R); *Venustaconcha ellipsiformis* (1L, 2R).
A	TU5/S1	155	1.3	-	-	-	

Stratum	Analytical unit[1]	Bag no.	Unidentifiable shell (g)	Identifiable shell			
				Weight (g)	Count (NISP)[2]	Charred (NISP)[2]	Taxa[3]
A	TU5/S1	257	2.4	4.1	2	0	*Elliptio dilatata* (1L); *Fusconaia flava* (1R).
A	TU5/S2	122	0.9	5.5	1	0	cf. *Lampsilis cardium* (1L).
A	TU5/S2	123	0.1	-	-	-	
A	TU5/S2	124	4.6	7	4	3	*Elliptio dilatata* (1L, 2R); *Venustaconcha ellipsiformis* (1R).
A	TU5/S2	264	4.5	4	1	-	*Ligumia recta* (1R).
A	TU5/S2A	160	6.1	8.6	5	0	*Alasmidonta marginata* (1L); *Elliptio dilatata* (1L); *Lampsilis cardium* (1L); *Strophitus undulatus* (1L, 1R).
A	TU5/S2A	161	0.1	1.6	1	0	Unionidae sp. (1R).
A	TU5/S2A	166	12.4	2.4	1	0	*Fusconaia flava* (1R).
A	TU5/S2A	167	1.3	3.6	1	0	*Venustaconcha ellipsiformis* (1R).
A	TU5/S2B	187	1.3	2.5	1	0	*Venustaconcha ellipsiformis* (1L).
A	TU5/S2B	190	0.7	-	-	-	
A	TU5/S2B	195	0.2	0.8	1	0	*Elliptio dilatata* (1L).
A	TU5/S2B	196	0.8	-	-	-	
A	TU5/L4	129	17.5	31.4	22	11	*Elliptio dilatata* (6L, 5R); *Fusconaia flava* (1L); *Lampsilis cardium* (1L); *Lampsilis* sp. (1L); *Strophitus undulatus* (1R); *Venustaconcha ellipsiformis* (1L, 2R); Unionidae spp. (4L).
A	TU5/L4	130	0.9	-	-	-	
A	TU5/F6	175	0.3	-	-	-	
A	TU5/F8	208	0.6	-	-	-	
A	TU5/F10 1	177	1.5	3	1	0	*Elliptio dilatata* (1R).
A	TU5/F10 1	186	1.2	-	-	-	
A-B	TU5/L6	201	1.4	0.9	1	0	*Lampsilis* sp. (1R).

Stratum	Analytical unit[1]	Bag no.	Unidentifiable shell (g)	Identifiable shell: Weight (g)	Count (NISP)[2]	Charred (NISP)[2]	Taxa[3]
A-B	TU5/L6	202	4.7	11.5	4	1	*Alasmidonta viridis* (1L); cf. *Fusconaia flava* (1R); *Venustaconcha ellipsiformis* (1L); Unionidae sp. (1R).
B	TU5/S3-5	131	23.8	36	35	17	*Actinonaias ligamentina* (1R); *Alasmidonta viridis* (2L, 4R); *Elliptio dilatata* (5L, 10R); *Fusconaia flava* (2R); *Lampsilis cardium* (1L); cf. *Lampsilis reeviana* (1R); *Pleurobema coccineum* (1L); *Venustaconcha ellipsiformis* (1L, 4R); Unionidae spp. (2L, 1R).
B	TU5/S3-5	132	2.6	2.7	2	1	*Elliptio dilatata* (1L); Unionidae sp. (1L).
B	TU5/S3-5	134	5.1	6.5	5	0	*Elliptio dilatata* (2R); *Venustaconcha ellipsiformis* (2L, 1R).
B	TU5/S3-5	143	1.3	3.5	2	1	*Elliptio dilatata* (1R); cf. *Lampsilis cardium* (1R).
B	TU5/S3-5	144	0.5	0.4	1	0	*Strophitus undulatus* (1R).
B	TU5/S3-5	205	0.3	1.1	1	0	*Elliptio dilatata* (1R).
B	TU5/S3-5	212	0.5	1.4	1	1	*Elliptio dilatata* (1L).
B	TU5/S3-5	214	2.1	0.1	1	0	*Strophitus undulatus* (1R).
B	TU5/S3-5	215	6.6	3.8	3	0	*Elliptio dilatata* (2R); *Lampsilis* sp. (1L).
B	TU5/S3-5	218	0.6	0.3	1	0	*Elliptio dilatata* (1L).
B	TU5/S3-5	219	-	4.9	3	1	*Elliptio dilatata* (1L, 2R).
B	TU5/S3-5	223	1.7	2.6	3	2	*Elliptio dilatata* (1R); *Venustaconcha ellipsiformis* (2R).
B	TU5/S3-5	233	2.4	-	-	-	
B	TU5/S3-5	235	2.1	0.7	2	1	*Strophitus undulatus* (1R); Unionidae sp. (1L).
B	TU5/S3-5	269	4.7	0.6	1	0	*Elliptio dilatata* (1R).

Stratum	Analytical unit[1]	Bag no.	Unidentifiable shell (g)	Identifiable shell Weight (g)	Count (NISP)[2]	Charred (NISP)[2]	Taxa[3]
B	TU5/F3	137	2.5	-	-	-	
B	TU5/F9	217	4.1	2.5	2	0	cf. *Lampsilis cardium* (1R); cf. *Venustaconcha ellipsiformis* (1L).
B-C	TU5/L11	240	1.3	11.5	3	0	*Alasmidonta viridis* (1R); *Elliptio dilatata* (1L); *Venustaconcha ellipsiformis* (1L).
B-C	TU5/L11	241	9.1	3.2	1	0	*Elliptio dilatata* (1L).
C	TU5/S7	254	2.2	-	-	-	
C	TU5/S7	255	1.8	4.9	2	0	*Lampsilis cardium* (1L); *Ligumia recta* (1R).
C	TU5/S7	275	1.6	8.6	3	0	*Elliptio dilatata* (1L, 1R); Unionidae sp. (1R).
C	TU5/S7	282	1.6	1.1	2	0	*Elliptio dilatata* (1R); *Lampsilis reeviana* (1R).
C	TU5/S7	283	0.8	1.9	2	0	*Elliptio dilatata* (1L); *Venustaconcha ellipsiformis* (1L).
C	TU5/S7	292	0.3	-	-	-	
E	TU5/S8	291	0.5	-	-	-	
E	TU5/S8	301	0.3	-	-	-	
E	TU5/S8	302	0.1	-	-	-	
A	TU7/S1	247	43.1	5.9	7	0	*Alasmidonta marginata* (1L); *Elliptio dilatata* (1L, 2R); *Lampsilis* sp. (1R); *Venustaconcha ellipsiformis* (1L, 1R).
A	TU7/S1	248	1.9	-	-	-	
A	TU7/S1	319	-	2.7	1	0	cf. *Lampsilis cardium* (1R).
A-B	TU7/L2	271	10.1	14	11	0	*Elliptio dilatata* (2R); *Fusconaia flava* (1R); cf. *F. flava* (1L); cf. *Lampsilis reeviana* (1L); cf. *Strophitus undulatus* (2R); *Venustaconcha ellipsiformis* (2L, 2R).

Stratum	Analytical unit[1]	Bag no.	Unidentifiable shell (g)	Identifiable shell Weight (g)	Count (NISP)[2]	Charred (NISP)[2]	Taxa[3]
A-B	TU7/L2	272	0.1	4.1	1	0	*Fusconaia flava* (1R).
B	TU7/S3	279	11.2	5.3	6	0	*Elliptio dilatata* (3L, 2R); *Venustaconcha ellipsiformis* (1R).
B	TU7/S3	280	11.3	4.4	3	0	*Elliptio dilatata* (1R); *Venustaconcha ellipsiformis* (2L).
E	TU7/S4	297	-	0.9	1	0	cf. *Elliptio dilatata* (1L).
-	Surface	1	4.5	-	-	-	
-	Surface	3	112.1	0.3	1	0	*Elliptio dilatata* (1R).
-	Surface	8	-	20.9	3	0	*Actinonaias ligamentina* (1R); *Lampsilis* sp. (1L); *Strophitus undulatus* (1L).
-	Surface	262	0.8	77.7	8	0	*Actinonaias ligamentina* (1L, 1R); *Alasmidonta marginata* (1R); *Lampsilis cardium* (1L); *Venustaconcha ellipsiformis* (3L, 1R).
-	Surface	263	-	9	1	0	*Alasmidonta marginata* (1R).
-	TU1/L1 Mixed	4	-	103.7	6	0	*Actinonaias ligamentina* (1L, 2R); *Fusconaia flava* (1L); *Lampsilis cardium* (2R).
-	Mixed	5	0.2	-	-	-	
-	Mixed	7	32.1	-	-	-	
-	Mixed	153	1.1	2.6	1	0	*Elliptio dilatata* (1L).
-	Mixed	178	0.2	0.3	1	1	*Elliptio dilatata* (1L).
-	Mixed	191	-	0.9	1	0	*Elliptio dilatata* (1R).
-	Mixed	230	4.7	3.7	1	0	*Elliptio dilatata* (1L).
-	Mixed	232	0.5	0.5	1	1	*Venustaconcha ellipsiformis* (1R).
-	Mixed	245	0.4	-	-	-	
-	Mixed	259	1.2	2.3	1	0	*Elliptio dilatata* (1R).
-	Unknown	333	1.1	-	-	-	

Stratum	Analytical unit[1]	Bag no.	Unidentifiable shell (g)	Identifiable shell: Weight (g)	Count (NISP)[2]	Charred (NISP)[2]	Taxa[3]
-	Unknown	?	-	9.9	1	0	*Amblema plicata* (1R).
Total			677.4	986.7	347	51	

[1]TU is Test Unit; S is Stratum; F is Feature; L is Level.
[2]NISP is number of identified specimens.
[3]L is left valve; R is right valve.

APPENDIX B

CURATION LIST OF ARTIFACTS RECOVERED

All material described in the following list of artifacts was recovered from 23PU235. Only one artifact, a grinding stone, was collected from 23PU2. Only one flake was recovered from 23PU255.

Bag Number	Provenience Data	Contents
101	Test Unit 2, SE½, Level 6	flakes, shatter, core, biface
103	Test Unit 2, SE½, Level 6, Flotation	flakes, shatter
104	Test Unit 2, SE½, Level 7	flakes, shatter, core, biface
106	Test Unit 2, SE½, Level 7, Flotation	flakes, shatter
107	Test Unit 2, SE½, Level 8	flakes, shatter, unifaces
109	Test Unit 2, SE½, Level 8, Flotation	flakes, shatter
110	Test Unit 2, Level 9	flakes, shatter
112	Test Unit 2, Level 9	flakes, shatter
113	Test Unit 2, SE½, Level 10, Fea. 2	flakes, shatter
116	Test Unit 2, Feature 2, Level 11	flakes, shatter, core, mano, bifaces
118	Test Unit 4, Level 1	flakes, shatter
122	Test Unit 4, Level 2	flakes, shatter
124	Test Unit 4, Level 3	flakes, shatter
125	Test Unit 4, Level 3, Flotation	core
126	Test Unit 2, Level 10, Fea. 2	flakes, shatter
129	Test Unit 4, Level 4	flakes, shatter, bifaces
130	Test Unit 4, Level 4, Flotation	flake
131	Test Unit 4, Level 5	flakes, shatter
134	Test Unit 4, Level 6	flakes, shatter
137	Test Unit 4, Level 7	flakes, shatter
143	Test Unit 4, Level 7	flake, shatter
145	Test Unit 3, Level 1	flakes, shatter, bifaces, ceramics
147	Test Unit 3, Level 1	ceramic
148	Test Unit 3, Level 2	flakes, shatter, bifaces, ceramics
151	Test Unit 3, Level 2, Flotation	burin, ceramic
153	Test Unit 4, Wall Scraping	flakes
154	Test Unit 5, Level 1	flakes, shatter
159	Test Unit 3, Level 3	flakes, shatter, biface
160	Test Unit 5, Level 2	flakes, shatter
161	Test Unit 5, Level 2, Flotation	flake. ceramic
164	Test Unit 2, Level 12	flake, shatter
166	Test Unit 5, Level 3	flakes, shatter
170	Test Unit 3, Level 4	flakes, shatter, biface
173	Test Unit 2, Level 13	flakes, shatter
175	Test Unit 5, Level 3, Flotation	flake
177	Test Unit 5, Level 3	flakes, shatter
178	Test Unit 5, Fea. 101, Cleaning	flakes, shatter
180	Test Unit 2, Level 14	flakes, shatter, biface
183	Test Unit 3, Level 5	flakes, shatter
187	Test Unit 5, Level 4	flakes, shatter
191	Test Unit 5, Level 4, Rodent	flakes, shatter
192	Test Unit 2, Level 15	noncultural
196	Test Unit 5, Level 5	flakes, shatter, core

Bag Number	Provenience Data	Contents
198	Test Unit 3, Level 6	flakes, shatter, biface
201	Test Unit 5, Level 6	flakes, shatter
202	Test Unit 5, Level 6	flakes, shatter
204	Test Unit 2, Level 15	flakes
205	Test Unit 5, Level 6, Fea. 7	flakes, shatter
207	Test Unit 5, Level 7, Fea. 8	flakes, shatter
208	Test Unit 5, Level 7, Fea. 8	flakes, shatter
209	Test Unit 3, Level 7, Flotation	flakes, shatter, biface
210	Test Unit 3, Level 7	flake
212	Test Unit 5, Level 8	flakes, shatter
214	Test Unit 5, Level 7, Flotation	flakes, shatter
215	Test Unit 5, Level 7	flakes, shatter, biface
217	Test Unit 5, Level 9, Fea. 9, Flot.	flakes, shatter
218	Test Unit 5, Level 9, Flotation	flakes, shatter
219	Test Unit 5, Level 9	flakes, shatter, bifaces
223	Test Unit 5, Level 9, Flotation	flakes, shatter
224	Test Unit 5, Level 9	flakes, shatter
226	Test Unit 6, Level 1	flakes, shatter, biface
227	Test Unit 6, Level 1, Flotation	flakes, shatter
230	Test Unit 5, West Wall	flakes
232	Test Unit 5, North Wall	flakes, shatter
233	Test Unit 5, Level 10	flakes, shatter
235	Test Unit 5, Level 10, Flotation	flakes, shatter
236	Test Unit 6, Level 1, Fea. 112	flakes, shatter, ceramic
237	Test Unit 6, Level 2	flakes, shatter, bifaces, ceramics
239	Test Unit 6, Level 2, Flotation	flakes, shatter
240	Test Unit 5, Level 11	flakes, shatter
241	Test Unit 5, Level 11	flakes, shatter
243	Test Unit 6, Level 3	flakes, biface
245	Test Unit 3, Wall Scraping	flake
246	Test Unit 6, Level 2, Flotation	flakes, shatter
247	Test Unit 7, Level 1	flakes, shatter, core, bifaces, ceramics
248	Test Unit 7, Level 1, Flotation	flakes, shatter, ceramics
251	Test Unit 6, Level 4	flakes, shatter, biface
253	Test Unit 6, Level 4, Flotation	flakes, shatter
254	Test Unit 6, Level 12, Flotation	flakes, shatter
255	Test Unit 5, Level 12	flakes, shatter
257	Test Unit 5, North Extension	flakes, shatter
259	Test Unit 5, Wall Scraping	flakes, shatter
261	Test Unit 6, Level 4, Fea. 104, Flot.	flakes, shatter
262	Surface	flakes, shatter, core
264	Test Unit 5, North Extension	flakes, shatter
266	Test Unit 6, Level 5	flakes, shatter

Bag Number	Provenience Data	Contents
267	Test Unit 6, Level 5, Flotation	flakes
269	Test Unit 5, North Extension	flakes, shatter
271	Test Unit 7, Level 2	flakes, shatter, bifaces
272	Test Unit 7, Level 2	flakes
275	Test Unit 5, North Extension	flakes, shatter
276	Test Unit 6, Level 6	flakes, shatter, biface
278	Test Unit 6, Level 6, Flotation	flakes, shatter
279	Test Unit 7, Level 3	flakes, shatter, biface
280	Test Unit 7, Level 3, Flotation	flakes, shatter
282	Test Unit 5, Level 13, Flotation	flakes, shatter
283	Test Unit 5, Level 13	flakes, shatter
286	Test Unit 6, Level 7, Flotation	flakes, shatter
287	Test Unit 6, Level 7	flakes, shatter, core, bifaces
288	Test Unit 6, Level 8	flakes, shatter
289	Test Unit 8, Level 8, Flotation	flakes, core
291	Test Unit 5, SW¼, Level 14, Flot.	flakes, shatter
292	Test Unit 5, NE¼, Level 14, Flot.	shatter
293	Test Unit 5, Level 14	flakes, shatter, biface
295	Test Unit 7, Level 4	flakes, shatter, biface, metate
298	Test Unit 6, Level 9	flakes, shatter, core, uniface, biface
300	Test Unit 6, Level 9, Flotation	flakes, shatter
301	Test Unit 5, Level 15	flakes, shatter
302	Test Unit 5, Level 15, Flotation	flakes, shatter
304	Test Unit 5, Level 15, F. 119, Flot.	flakes
307	Test Unit 7, Level 5, Flotation	flakes
308	Test Unit 6, Supplement	flakes, hammerstone
309	Test Unit 6, Level 10	flakes, shatter
310	Test Unit 6, Level 10, Flotation	flakes
312	Test Unit 5, Level 16, Flotation	flakes, shatter
313	Test Unit 5, Level 16	flake, shatter
315	Test Unit 6, Level 11	flakes, shatter
317	Test Unit 6, Level 11, Flotation	flakes, shatter
322	Test Unit 6, Level 12, Flotation	flakes, shatter
323	Test Unit 6, Level 12	flakes, shatter
324	Test Unit 6, Supplement	shatter
325	Test Unit 6, Supplement	flakes
332	Test Unit 2, Profile	hammerstone